CONGRESS SPECIAL NUMBER

VOLUME 116 NUMBER 9 SEPTEMBER 1960

THE BRITISH VETERINARY JOURNAL

Editor
J. A. LAING

Editorial Board
J. N. RITCHIE, *Chairman*

R. A. ALEXANDER (South Africa)
W. G. BEATON (Kenya)
I. S. BEATTIE (Edinburgh)
SIR THOMAS DALLING (Rome)
J. FRANCIS (Australia)
C. S. GRUNSELL (Bristol)
J. A. HENDERSON (Canada)
W. M. HENDERSON (Brazil)
J. R. M. INNES (United States)
H. G. LAMONT (Belfast)
R. S. MARSHALL (London)
J. C. NEWHOOK (New Zealand)
E. J. L. SOULSBY (Cambridge)
W. L. WEIPERS (Glasgow)
E. G. WHITE (Liverpool)

LONDON
BAILLIÈRE, TINDALL AND COX LTD
7 AND 8 HENRIETTA STREET
W. C. 2

UNIVERSITY OF SYDNEY

LECTURESHIP/SENIOR LECTURESHIP IN

ANIMAL HUSBANDRY

Applications are invited for the above-mentioned position. Applicants should be qualified in grassland management. The appointee will be stationed at the University of Sydney Animal Husbandry Farms, Camden, N.S.W., and will be given ample time and facilities for research.

The salary for a Senior Lecturer is within the range £A2,550 x 95—£3,000 per annum; for a Lecturer within the range £A1,730 x 105—£2,435 per annum. In each case cost of living adjustments will be allowed. The salary is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in Australia and London on *15th September, 1960.*

HONG KONG

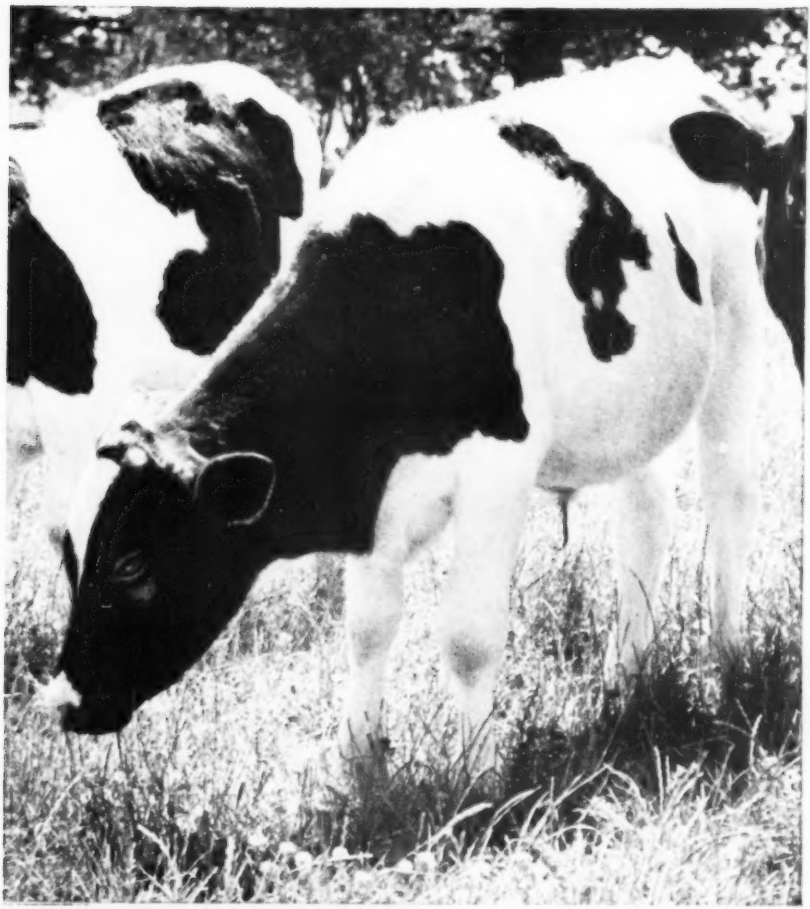
Male Specialist Virologist required to take charge of Vaccine Institute and manufacture of human and animal vaccines. Candidates must possess qualifications registrable in United Kingdom and have had a minimum of seven years post graduate experience, at least five of which must have been spent in the practice of virology.

Appointment on permanent basis with pension (non-contributory) or on contract for 3 years with gratuity payable on satisfactory completion of contract.

Salary £3,675 p.a. Income Tax at local rates.

First-class passages for officer, wife and up to three children. Government quarters normally provided at nominal rental.

Application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 117/51/062.



HUSK *is no longer a problem*

Treatment with **'FRANOCIDE'...**

. . . was successfully carried out in tens of thousands of cattle last year . . . stops further lung damage immediately by elimination the migrating larvae of Dictyocaulus viviparus *(known to be primarily responsible for the lung lesions) . . . leads to a dramatic reduction in the number of larvae passed in the faeces—thereby reducing pasture contamination . . . leads to improvement even in cases where lung damage was present before the commencement of treatment . . . leaves calves immune to further attacks.*

'Franocide'

Diethylcarbamazine Citrate Injection (Veterinary)
A sterile solution in bottles of 100 c.c.

BURROUGHS WELLCOME & CO. (The Wellcome Foundation Ltd.)
The Wellcome Building, Euston Road, London N.W.1
Tel: EUS 1177 and 18 Merrion Square, Dublin. Tel: 65751/2

16618

UNIVERSITY OF SYDNEY

LECTURESHIP/SENIOR LECTURESHIP IN ANIMAL HUSBANDRY

Applications are invited for the above-mentioned position. Applicants should be qualified in grassland management. The appointee will be stationed at the University of Sydney Animal Husbandry Farms, Camden, N.S.W., and will be given ample time and facilities for research.

The salary for a Senior Lecturer is within the range £A2,550 x 95—£3,000 per annum; for a Lecturer within the range £A1,730 x 105—£2,435 per annum. In each case cost of living adjustments will be allowed. The salary is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in Australia and London on *15th September, 1960.*

HONG KONG

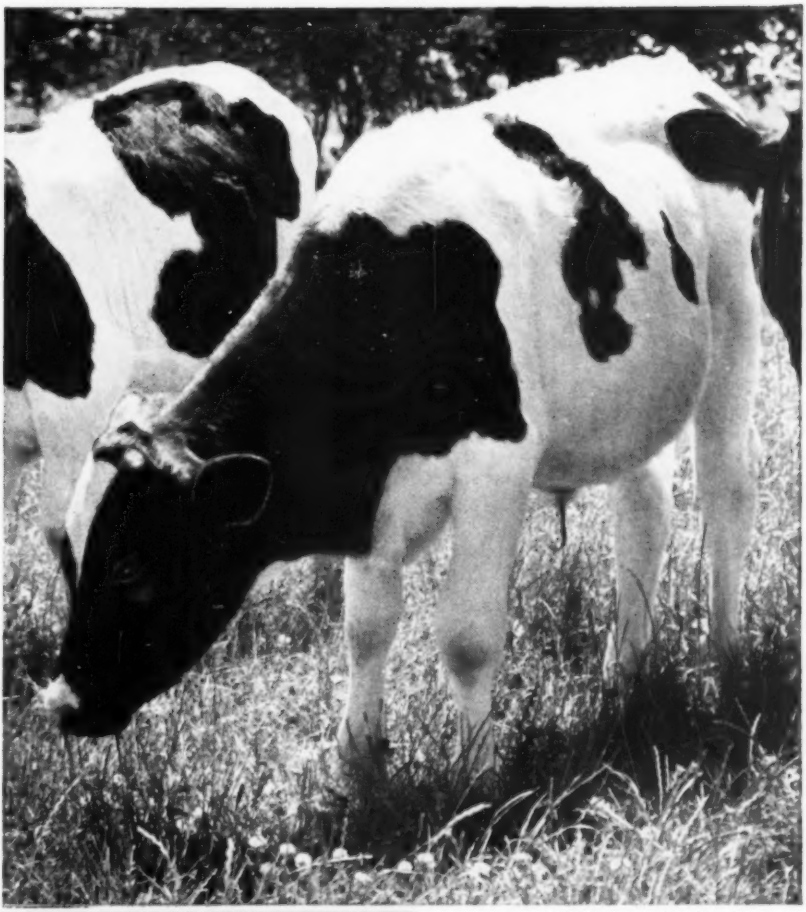
Male Specialist Virologist required to take charge of Vaccine Institute and manufacture of human and animal vaccines. Candidates must possess qualifications registrable in United Kingdom and have had a minimum of seven years post graduate experience, at least five of which must have been spent in the practice of virology.

Appointment on permanent basis with pension (non-contributory) or on contract for 3 years with gratuity payable on satisfactory completion of contract.

Salary £3,675 p.a. Income Tax at local rates.

First-class passages for officer, wife and up to three children. Government quarters normally provided at nominal rental.

Application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 117/51/062.



HUSK *is no longer a problem*

Treatment with **'FRANOCIDE'...**

... was successfully carried out in tens of thousands of cattle last year ... stops further lung damage immediately by eliminating the migrating larvæ of Dictyocaulus viviparus *(known to be primarily responsible for the lung lesions) ... leads to a dramatic reduction in the number of larvæ passed in the fæces—thereby reducing pasture contamination ... leads to improvement even in cases where lung damage was present before the commencement of treatment ... leaves calves immune to further attacks.*

'Franocide'

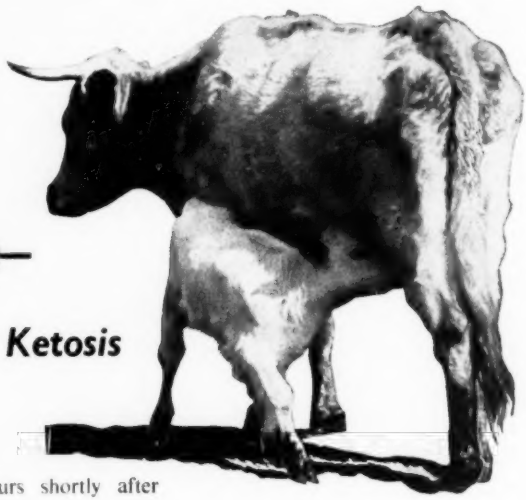
Diethylcarbamazine Citrate Injection (Veterinary)
A sterile solution in bottles of 400 c.c.

BURROUGHS WELLCOME & CO. (The Wellcome Foundation Ltd.)
The Wellcome Building, Euston Road, London N.W.1
Tel: EUS 4477 and 18 Merrion Square, Dublin, Tel: 65751/2

14630

Simple–
Rapid–
Effective–

control of Bovine Ketosis



Post-partum ketosis which occurs shortly after parturition and the serious losses due to this condition can now be minimized and controlled by

DI-ADRESON-F* (VETERINARY)

Most cases respond fully to a single intramuscular injection (100 mg.) without additional treatment, even in animals which have previously failed to respond to other forms of treatment.

Di-Adreson-F* (Veterinary), in 10 ml. vials each containing 10 mg. per ml. Prednisolone in aqueous suspension is approximately 5 times as active as cortisone or hydrocortisone and provides rapid physiological effect with ease of administration.

Reference: Shaw, J.C. (1955) Advances in Vet. Sci. *ii*, 262-360.
Huber, W.G. (1958) Vet. Med., *53*, 55.
Link, R.P. et al (1957) J. Amer. vet. med. Ass., *130*, 137.

**Registered Trade Mark*

ORGANON

Sole Veterinary Distributors in the United Kingdom and Republic of Ireland:
C. J. Hewlett & Son Ltd., King George's Avenue, Watford
Telephone: Watford 34101 (4 lines) Telegrams: Pepsine, Watford

The British Veterinary Journal

SEPTEMBER 1960

The whole of the matter appearing in "The British Veterinary Journal" is copyright and may not be reproduced in whole or in part without permission. (For notices to contributors see outside back cover.)

CONTENTS

General Articles

Vaccination Against Johne's Disease 294
T. M. Doyle

The Use of the Haemagglutination Technique for the Detection of Antibodies in Gastro-intestinal Nematode Infections of Sheep 302
E. J. L. Soulsby

An Analysis of Cattle Population Trends and Cattle Ownership in Selected Areas of Nyasaland 322
K. W. Aspinall

Share Jones Memorial Lecture 337
H. V. Hughes

Reviews 350

News and Trade Announcements 352

CONTROLLED sedation and anaesthesia with

MONOVEN or TRINAVEN

TERMINATED at will—with

MEGIMIDE SODIUM

Rubens study by courtesy of the British Museum Trustees

MONOVEN*
is available in 50 ml. and 100 ml. vials.

TRINAVEN*
is available in 100 ml. vials.

MEGIMIDE* SODIUM
is available in boxes of 6 ampoules each containing 143 mg. Megimide Sodium equivalent to 125 mg. Megimide with 6 ampoules of 5 ml. Water for Injection B.P. Vials 2.86 G. Megimide Sodium equivalent to 2.5 G. Megimide.

Large animal anaesthesia is now a relatively simple and safe operation with MONOVEN and TRINAVEN sterile pentobarbitone sodium solutions by slow intravenous injection. The usual prolonged recovery period has been effectively removed with the advent of MEGIMIDE Sodium which will return all species to immediate consciousness. Calves and adult cattle can be on their feet within 15 minutes of full anaesthesia.

***REGD. TRADE MARKS**

Available to the VETERINARY PROFESSION only.

Full literature on request.

TRADE MARK

THE HOUSE OF HEWLETT
ESTABLISHED 1832

Megimide Sodium is manufactured by Aspro-Nicholas Ltd., for the Sole Veterinary Distributors

C. J. Hewlett & Son Ltd.

KING GEORGE'S AVENUE, WATFORD, HERTS.

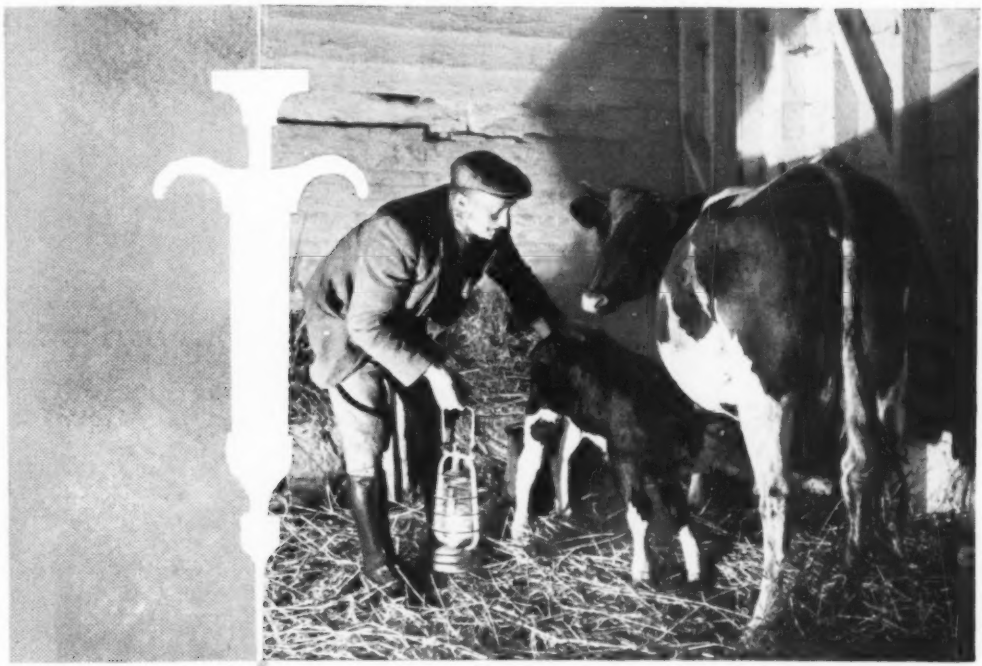
Telephone: Watford 34401. Telegrams & Cables: Pepsine Watford

H.P. 105

... by fertility out of

Dinovex

TRADE MARK



In the treatment of functional sterility Dinovex Oestrogenic Solution provides:

- Oestrogen **during** oestrus
- Direct stimulation of the maturing follicle to ovulate
- More rapid absorption and elimination
- Reduced risk of cysts and of prolonged luteinization
- Low cost treatment

Cartons of six 5 c.c. vials each containing 1 mg. dioestrol per c.c. of solution for subcutaneous injection

LITERATURE ON REQUEST

Ortho Pharmaceutical Limited
Veterinary Division
Saunderton · Buckinghamshire

BRITISH VETERINARY CODEX

Supplement 1959

The number of new medicaments which have been introduced and the improvements in methods of formulation which have been devised since the British Veterinary Codex was published have made it necessary to issue a supplement to the main volume.

The Supplement contains 89 additional monographs of which 47 provide standards for new drugs, 7 for vaccines and antisera and 35 for new formulæ, with a number of additions to and amendments of the appendixes. As with the main volume there is a comprehensive therapeutic and pharmacological index. In addition, the Supplement amends a number of the monographs of the British Veterinary Codex (45s.). Whenever applicable comprehensive details are given of the action and uses and doses of the substances described.

Pp. xviii + 134 Price 35s. *(packing and postage 1s. 3d. inland, 2s. overseas)*

THE PHARMACEUTICAL PRESS

17, Bloomsbury Square, London, W.C.1

Ready shortly

RADIOGRAPHY FOR THE VETERINARY SURGEON

By R. N. Smith. About 96 pp.
36 illustrations. Approx. **18s. 6d.**

Presents an account of the phenomena and techniques involved in making radiographs, the special problems to be solved, and the use in animal work of the different types of picture obtained.

Ready in December

THE VETERINARY ANNUAL

1960 Edition

Edited by W. A. Pool. About 400 pp.
Illustrated. Subscription **38s. 6d.**, post free

Gives a survey of the recent literature and a careful evaluation of present day work in the veterinary field.

ORDER NOW — after publication the price is **42s.**, postage **1s. 9d.**

WRIGHT'S of BRISTOL

★

Three Important Books

AN INTRODUCTION TO VETERINARY PHARMACOLOGY

By FRANK ALEXANDER, Ph.D., D.Sc., M.R.C.V.S.

188 pages. 25 illustrations. 20s.

LEPTOSPIROSIS IN MAN AND ANIMALS

By J. M. ALSTON, M.D., F.R.C.P.Ed., and J. C. BROOM, O.B.E., M.D.

380 pages. 40 illustrations. 40s.

THE U.F.A.W. HANDBOOK on the Care and Management of Laboratory Animals

Second Edition. Edited by A. N. WORDEN, M.A., B.Sc., M.R.C.V.S., and W. LANE-PETTER, M.A., M.B., B.Chir.

972 pages. 339 illustrations. 70s.

E. & S. LIVINGSTONE, LTD.
TEVIOT PLACE, EDINBURGH

★

GLAXO

OVILIN

first and only vaccine to protect against four diseases

Pulpy Kidney AND Braxy AND Blackleg AND Tetanus

Ovilin is a product of Glaxo's own research and development. Here, for the first time, is a safe and effective multivalent vaccine to protect against not simply one but four sheep diseases. It is safe because it is highly purified and its effectiveness has been proved by laboratory tests and direct challenge.

This fourfold protection offered by Ovilin costs little more than protection against just one disease. Details of prices, discounts and quantity rates are readily obtainable.

TECHNICAL DATA : *Ovilin is a highly concentrated vaccine containing aluminium treated purified toxoids of Cl. welchii Type D, Cl. septicum and Cl. tetani, with purified, aluminium treated, formol culture of Cl. chauvoei. It is presented as a ready-to-use free flowing suspension. Dosage is 2 ml given subcutaneously.*

OVILIN TRADE MARK

the product to revolutionise sheep vaccination in this country is available NOW

PENICILLIN

STREPTOMYCIN

now combined in the ONE VIAL

Ready-prepared

'DISTAVONE'
SUSPENSION
VETERINARY

Procaine penicillin combined with dihydrostreptomycin

'DISTAVONE'
TRADE MARK

ALSO AVAILABLE IN NEW 75 ml. VIAL

DC·B·L

THE DISTILLERS COMPANY (Biochemicals) LIMITED

Broadway House, The Broadway, Wimbledon, London, S.W.19
Telephone: LIBerty 6600

Owners of the trade mark 'Distavone'

APH2/60A

The canine vaccine without equivalent

DOVAX

Combined Canine Distemper and Hepatitis Vaccine
Distemper Component —chick embryo origin
Hepatitis Component— ferret tissue culture origin

DOVAX—a product of Connaught Medical Research Laboratories—was first issued early in 1958—after extensive clinical trial. It has gained during the past two years an international reputation as the foremost product for canine immunization. "Dovax" is backed by the reputation and resources of the organisation who pioneered "Disvax" (egg-adapted living) Distemper and Hardpad Vaccine in 1953 after several years' research and clinical evaluation.

Safe, effective, triple protection from the one single injection

DOVAX *

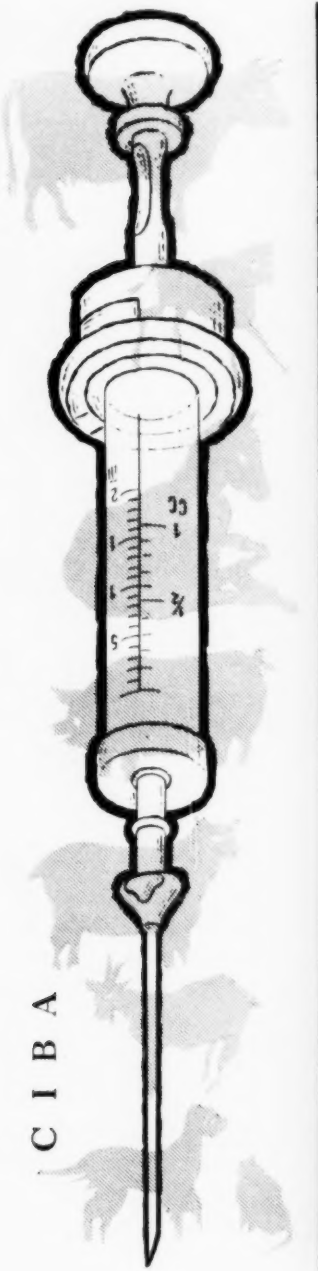
THE FIRST TRIPLE PROTECTION VACCINE AND STILL TECHNICALLY SUPERIOR TO ANY OTHER

*

"DISVAX" Canine Distemper Vaccine (chick embryo origin) and "HEPROVAX" Infectious Canine Hepatitis Vaccine (modified live virus)—ferret tissue culture origin) are both available for use when triple protection is considered unnecessary.

Technical literature available on request.

WILLOWS FRANCIS LIMITED
73/75 SHACKLEWELL LANE LONDON E8
Telephone: CLIssold 6361 (5 lines) Grams: Forty Hack, London.



STOP PRESS

VETIDREX tablets for SMALL ANIMALS and maintenance therapy in large animals

The first potent injectable diuretic for cattle

Vetidrex
(hydrochlorothiazide)

for all oedemas

10 ml. vials 50 mg./ml. boxes of 1 and 5.

Vecortenol
(prednisolone trimethylacetate)

The longest-acting corticosteroid for depot therapy

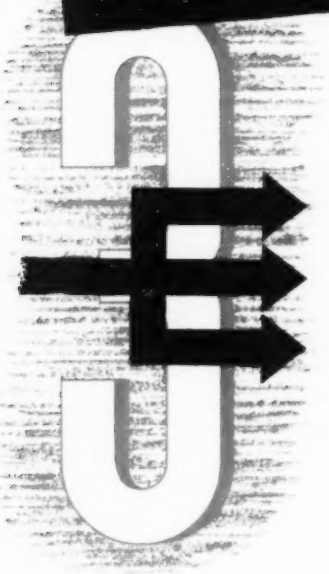
4 ml. and 10 ml. vials 25 mg./ml.

Both products of CIBA research

'Vetidrex' and 'Vecortenol' are registered trade marks

CIBA Laboratories Limited, Horsham, Sussex

For scour and enteritis



Three-pronged attack gives rapid and efficient control

'Stromez', which contains appropriate therapeutic doses of '*Sulphamezathine*' (Sulphadimidine B.P.), *streptomycin* and *kaolin*, provides the simultaneous local and systemic treatment so essential for the efficient control of enteritis. Systemic treatment is assured by the high and sustained blood levels produced by 'Sulphamezathine'. This reinforces the prolonged localised action in the gut of slowly absorbed streptomycin. In addition kaolin provides valuable supplementary effect by its absorbent and detoxifying action.

Invaluable in all acute cases of enteritis, particularly when secondary infection is apparent, 'Stromez' is also a safeguard against the break-though of tetracycline-resistant strains of *Bact. coli.*

Available to veterinary surgeons only.

Issued in boxes each containing 5 x 100 gramme envelopes from which the product name can be torn off, leaving a blank label for directions.

Stromez

Trade Mark

IMPERIAL CHEMICAL INDUSTRIES LIMITED PHARMACEUTICALS DIVISION WILMSLOW CHESHIRE

PH11

The skilled hand of the Veterinary Surgeon . . .

reaches with confidence for . . .

'XYLOTOX' (REGD)

Veterinary self-sterilising Local Anæsthetic

for safe, deep, prolonged anæsthesia
and extreme rapidity of action.
You can be certain of XYLOTOX.

WILLOWS FRANCIS LTD
73/75 SHACKLEWELL LANE LONDON E8
Tel: CLissold 6381 (3 Lines) Grams: Forty Hock London

MAKERS OF VETERINARY SPECIALITIES
EXCLUSIVE TO THE PROFESSION SINCE 1751

NARPHEN *is the SNP brand of phenazocine (2'-hydroxy-5,9-dimethyl-2-phenethyl-6,7-benzomorphan hydrobromide). It is a new synthetic analgesic more powerful than morphine and with fewer and less pronounced side effects. Weight for weight, it does not induce stupor or sedation to the same degree as morphine and other narcotic drugs.*

NARPHEN

MORE POWERFUL THAN MORPHINE

- NARPHEN is many more times effective than morphine as an analgesic in the dog.
- It is quicker-acting and longer-lasting in effect than morphine or pethidine.
- Side effects such as respiratory depression, hypotension, nausea and vomiting are rare after therapeutic doses.

NARPHEN Veterinary is indicated in severe acute or chronic pain in the dog, especially as an adjunct to general anaesthetics and to relieve pain post-operatively.

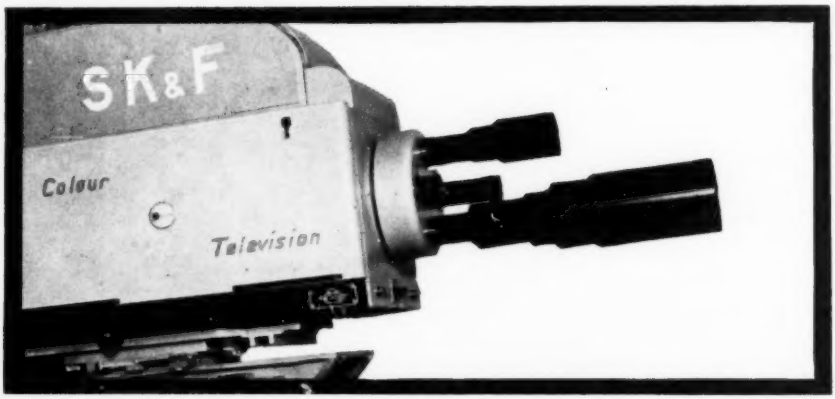
NARPHEN *is subject to the Dangerous Drugs Regulations.*

NARPHEN Veterinary is available in boxes of 10 and 100 1.1 ml. ampoules each containing 2 mg. per 1 ml.

Smith & Nephew *Pharmaceuticals* Limited

WELWYN GARDEN CITY • HERTFORDSHIRE

COLOUR TELEVISION AT THE B.V.A. CONGRESS



Following its highly successful introduction to the veterinary profession at the 1960 B.S.A.V.A. Congress in March, Colour Television will again be sponsored and arranged by Smith Kline & French Laboratories Ltd. at the B.V.A. Congress in Glasgow from Aug. 29th to Sept. 3rd. We hope that the occasion will provide an opportunity for a great many members of the profession to witness the outstanding effectiveness of this new and powerful medium in the teaching of surgical and clinical procedures.

Smith Kline & French Laboratories Ltd,
Welwyn Garden City, Herts

CTV.VA90

Canine antisera

Are you paying too much for too little?

PADISAN gives protection against distemper and hard pad at less cost than you're paying for your present distemper antiserum.

DISTEMPER

PADISAN provides a passive 14-day immunity

HARD PAD

PADISAN provides a passive 14-day immunity

LEPTOSPIROSIS

PADISAN contains an antileptospirosis component, effective against latent infections of both L icterohaemorrhagiae and L canicola

OTHER ANTISERA

In addition to Padisan, a range of canine antisera is available to cover all the major dog diseases.

Canine Hepatitis Antiserum
Leptospira Antiserum *(for both L. icterohaemorrhagiae and L. canicola)*

HEDISAN *(Combined Canine Distemper, Hard Pad and Hepatitis Antiserum)*

Padisan

COMBINED CANINE DISTEMPER—HARD PAD ANTISERUM, WITH AN ANTILEPTOSPIROSIS COMPONENT

For your files : If you would like to have fuller information about PADISAN, and also about our related vaccines and antisera, write to:
HOECHST PHARMACEUTICALS LTD., VETERINARY DIVISION, SLOUGH

Sole distributors in the United Kingdom: HORLICKS LIMITED, SLOUGH, BUCKS
Telephone: SLOUGH 22322 (6 lines). **Telegrams:** HORLICK, SLOUGH

in cases of **BOVINE KETOSIS**

rapid and sustained recovery with

DELTACORTRIL*

Brand of prednisolone

INTRAMUSCULAR VETERINARY

* Trade Mark

Specify Deltacortril for the treatment of Bovine Ketosis to anticipate the most satisfactory recovery rate. The recommended dose of 10 ml. produces a sustained recovery in most treated cows cutting repeat visits to a minimum. Milk output is restored to its pre-ketotic level in 4-5 days and appetite shows a marked improvement even before ketonaemia is eliminated.

AVAILABILITY. Vials of 10 ml. Deltacortril containing 100 mg. prednisolone.

DOSAGE. The normal dose is 10 ml. by intramuscular injection.

Pfizer PFIZER LTD · FOLKESTONE · KENT

2144

THE BRITISH VETERINARY ASSOCIATION CONGRESS, GLASGOW, 1960

It was in 1938, just twenty-two years ago, that a veterinary congress was last held in the city of Glasgow, in a year especially memorable to all of us as the year of the Munich agreement, to Glaswegians as the year of the Empire Exhibition that was held there, and to the veterinary profession as the year when the 13th International Veterinary Congress was held in Zurich under the Presidency of Professor Leclainche, two weeks before the National Veterinary Medical Association Congress took place. Now, once more, the Congress is being held in Glasgow and our readers will be interested to note from the Programme printed below that the papers have a strong bias towards the clinical, a bias that is in line with the traditions of veterinary practice in the south-west of Scotland and of the Glasgow Veterinary School. We are sure that those attending the Congress will fall in with another Glasgow tradition, that of combining hard work with pleasure and no doubt many of them will take advantage of the break in the programme on the Wednesday and go "doon the water", for there are few great cities in the world that have surroundings as beautiful as Glasgow and those who take a trip down the Clyde or pay a visit to the three lochs will not soon forget their visit to Scotland.

PROGRAMME

Sunday, August 28th

2.30 p.m. Congress Office opens (Queen Margaret Union, University of Glasgow.)

6.30 p.m. Annual Congress Service in the University Chapel.

7.45 p.m. Council Meeting in the University of Glasgow Men's Union.

Monday, August 29th

9.30 a.m. Official Opening of the Congress in the Bute Hall, University of Glasgow.

11.15 a.m. Group Photograph at the South Front of the University.

11.45 a.m. Annual General Meeting of the Association in the Bute Hall.

The Scientific Programme

Monday, August 29th

2.30 p.m. Symposium on Brucellosis.

The Prophylaxis of Brucellosis in Cattle: Dr. A. McDiarmid.
Eradication in Northern Ireland: Dr. W. R. Kerr.
Eradication in the Netherlands: Dr. G. M. van Waveren.
Epidemiology and Prevention of Human Brucellosis: Dr. P. W. Bothwell.

3.45 p.m. Case-reporting session.

4.45 p.m. Films.

Tuesday, August 30th

9.30 a.m. Symposium on Poultry Disease and the Practitioner.

Infectious Diseases: J. D. Blaxland.
Leucosis and Fowl Paralysis: W. A. M. Gordon.
Coccidiosis: Dr. C. Horton-Smith.
Nutrition and Nutritional Diseases: W. W. C. Gibson.

9.30 a.m. Symposium on Disorders of Calcium Metabolism.

Experimental Studies of the Relationship between the Calcium-Phosphorus Ratio of the Diet and Fertility in Heifers: A Preliminary Report: A. Littlejohn and E. Lewis.
Some Aspects of Hypocalcaemia in Cattle: Dr. E. W. Moodie.
Calcium-Iron Relationships in the Fattening Pig: Dr. W. A. Greig.
The Effect of Calcium and Phosphorus Deficiency on Bone Growth in the Dog: J. R. Campbell.

12.00 noon Plenary Session: The Economics of Animal Health: Professor W. I. B. Beveridge.

2.30 p.m. Surgical Demonstrations (Televised): Veterinary Hospital.

Wednesday, August 31st

2.30 p.m. Films: University.

Thursday, September 1st

9.30 a.m. Symposium on Disease of the Bovine Foot.

Applied Anatomy: J. A. Taylor.
Surgery of the Bovine Foot: Dr. G. H. Arthur.
The Clinical Problem: C. Wood.

9.30 a.m. Symposium on Diseases of Sheep.

The Prevention of Pulpy Kidney Disease: Dr. R. F. Montgomerie.
Sudden Death in Sheep: Dr. J. A. A. Watt.
Experimental Scrapie: Some Recent Work: J. M. K. Mackay, W. Smith and J. T. Stamp.
Anaemia in Trichostrongyloid Infections: Dr. J. A. Campbell and A. C. Gardiner.

12.00 noon Plenary Session: Veterinary Education: Professor W. L. Weipers

2.30 p.m. Demonstrations (Televised).

(i) Measurement and Description of Horses: J. McC. Ingram.
(ii) The Examination of Horses for Soundness—A Preview of the British Veterinary Association's Recommendations: C. Davenport.
(iii) Case Presentations.

Friday, September 2nd

9.00 a.m. Symposium on Husk.

The Disease Process: Dr. W. F. H. Jarrett, F. Jennings, Drs. W. I. M. McIntyre and W. Mulligan, N. C. C. Sharp and Dr. G. M. Urquhart.
Treatment with Cyanacethydrazide: Dr. J. K. Walley.
Treatment with Diethylcarbamazine: W. H. Parker.
Recent Experiences with Vaccination: Dr. D. Poynter and B. V. Jones.

11.30 a.m. Experiences with a Scheme for Supervising Pig Herds believed to be Free from Enzootic Pneumonia (Virus pneumonia): Drs. R. F. W. Goodwin and R. Whittlestone.

Some Common Surgical Entities in the Budgerigar: L. Arnall.

2.30 p.m. Radiography in Small Animals: D. D. Lawson.

3.30 p.m. Symposium on Enteric Diseases of Calves.

Husbandry in Relation to Calf Diarrhoea: A Review: Professor J. S. S. Inglis.
The Ecology of the Intestinal Bacteria with special reference to *E. coli:* Dr. H. Williams-Smith.
Infection by *E. coli* and Salmonella: P. L. Ingram and Professor R. Lovell.
Antibiotics and Calf Diarrhoea: R. G. Dalton, E. W. Fisher and W. I. McIntyre.

5.00 p.m. Films.

The Social Programme

Sunday, August 28th

8.15 p.m. West of Scotland Division "At Home" and Film Show: University of Glasgow Men's Union.

Monday, August 29th

1.30 p.m. Visit to Johnnie Walker Ltd.
8.00 p.m. Civic Reception: City Chambers, George Square.

Tuesday, August 30th

10.30 a.m. Fashion Show.
4.00 p.m. University of Glasgow Reception: Veterinary Hospital.
7.30 for 8.00 pm. Annual Banquet: Central Hall.

Wednesday, August 31st

10.00 a.m. Cruise to the Kyles of Bute by R.M.S. *Queen Mary II* from Bridge Wharf.
8.00 p.m. Edinburgh Tattoo: 1st performance Bus leaves Glasgow at 6.15 p.m.
10.30 p.m. Edinburgh Tattoo: 2nd performance Bus leaves Glasgow at 8.30 p.m.

Alumnus Society Dinners

Thursday, September 1st

11.30 a.m. Ladies tour to the Trossachs.
1.30 p.m. Visit to Johnnie Walker Ltd.
2.30 p.m. Golf Competition: Hilton Park. [Entries to be sent to Dr. T. A. Douglas, Dept. of Biochemistry, The Veterinary Hospital, Bearsden, Glasgow.]
8.00 p.m. Ladies Guild Dance: Central Hall.

Friday, September 2nd

8.00 p.m. President's Reception: Central Hotel

Saturday, September 3rd

9.30 a.m. Adjourned Annual General Meeting of the Association. First Meeting of B.V.A. Council, 1960-61. Engineering Department, University of Glasgow.

VACCINATION AGAINST JOHNE'S DISEASE

By T. M. Doyle

Central Veterinary Laboratory, Weybridge

Johne's disease of cattle and sheep is world-wide in its distribution and is being gradually introduced into new areas by carrier animals. It is a major disease of sheep in Iceland where it is now being controlled by vaccination (Sigurdson, 1956, 1960). The geographical distribution of the disease in sheep is in general similar to that of cattle. No serious attempt is being made in any country to control the disease in cattle. This attitude is probably influenced by its high incidence and the technical difficulties inherent in its diagnosis and investigation, but it is obviously a short-sighted policy.

The results of complement-fixation tests suggest that a considerable proportion of animals contract infection without exhibiting symptoms, but the majority overcome it, only 5 to 10 per cent. on average developing clinical disease. But complement-fixing antibodies may persist for a variable time in the serum, although infection has been eliminated. This creates a difficulty ; the test indicates the presence of antibody, but it does not necessarily follow that the animal is still infected. Minett (1933) observed that in " Johne's disease herds " the proportion of reactors to the johnin test not uncommonly averaged 30 to 40 per cent. Larsen and Vardaman (1959) found that 85 per cent. of young stock in an infected herd reacted to the johnin test before they reached one year of age and lost their sensitivity within 15 months ; during the same period 48 per cent. of adult cattle reacted. The intradermal test was claimed to be the method of choice based on *post-mortem* findings. Hebert and Paterson (1955) showed non-specific reactions in attested herds to be 30 per cent. to avian tuberculin and 17 per cent. to mammalian ; there was no information whether *Mycobacterium johnei* infection contributed to these reactions. Sikes and Groth (1950) made 855 tests with mammalian tuberculin on cattle naturally infected with Johne's disease and free from tuberculosis. When tests were read at the 72nd hour, 31.8 per cent. were either positive or suspicious. They suggested that many mammalian tuberculin reactors, with no visible lesions of tuberculosis on *post-mortem* examination, may have been sensitized by *M. johnei*. The observations of Taylor (1949, 1950) and Smith (1954) that 15–17 per cent. of apparently normal abattoir cattle were carriers of *M. johnei* is evidence of the considerable incidence of the disease and a pointer to it as a possible cause of non-specific tuberculin reactions.

IMMUNIZATION AGAINST JOHNE'S DISEASE

Vallée (1924) immunized cattle by the subcutaneous inoculation of living *M. johnei* suspended in an unabsorbable medium. His method was based on

the work of Twort and Ingram (1913) and M'Fadyean and Sheather (1916), who suggested that the subcutaneous inoculation of living *M. johnei* was innocuous, but as in their combined experiments only three animals were inoculated subcutaneously, there is little evidence on this point. Vallée, Rinjard and Vallée (1934) claimed that even virulent strains could be safely inoculated subcutaneously. There is, however, no proof that the subcutaneous inoculation of virulent strains is always devoid of danger, and to use them for the preparation of vaccine would be an unjustifiable risk. Until more evidence is obtained on this point only avirulent strains should be used. Because of the long incubation period after inoculation—at least one year—many animals could be infected, if insufficiently attenuated strains were used, before evidence of it was manifest. The vaccine strains in use at Weybridge are living, but have become avirulent through age.

Doyle (1956) reviewed the pioneer work on vaccination carried out by Vallée (1924) and by Vallée *et al.* (1924, 1934, 1941) in France and the extensive immunization work on sheep by Sigurdsson (1956, 1960) in Iceland. It will be sufficient here to state that both in France and Iceland vaccination has proved of great value.

THE STANDARD VACCINE

The vaccine consists of living, avirulent strains of *M. johnei* suspended in equal parts of liquid paraffin and olive oil to which some powdered pumice is added. Five mg. of moist-dried culture suspended in the oily mixture are injected subcutaneously on the side of the sternum or on the side of the neck. An inflammatory swelling about the size of a walnut develops at the site of injection which is gradually replaced by a fibro-caseous nodule that persists from six months to two years or longer.

IMMUNITY AS THE RESULT OF VACCINATION

The vaccine does not confer a true immunity ; it is believed to protect as long as the acid-fast bacilli are present in the nodule and when these are eliminated the animal becomes as susceptible as non-vaccinated animals of the same age group. The duration of protection is difficult to estimate because of the gradual development of age resistance. But the examination of nodules has shown that the time bacilli persisted in them varied with individual animals from 15 to 30 months. The presence of a nodule should not be regarded as indicative of protection as they sometimes persist long after the *M. johnei* have been eliminated. It would appear from field experience that revaccination is necessary in heavily infected herd. When it is not carried out there is a risk of a few animals developing clinical disease between two and five years of age and keeping the infection going in the herd. There is no optimum time for revaccination. If a sensitized animal is revaccinated, the inoculum may be absorbed or it may be ejected by abscess formation and if revaccination is delayed, the animal may remain for a period unprotected.

Theoretically, revaccination should be carried out when sensitivity is waning or when the nodule is regressing. As it is necessary to state a time for revaccination, it is recommended that it should be done at about 18 months of age.

FIELD TRIAL OF THE VACCINE

The vaccine described above has been under trial since 1946 in infected herds situated in different areas of England, Scotland and Wales so as to embrace the various breeds of cattle, types of farming, soil, etc. There was little supervision of the majority of the herds, and nothing was known of the hygienic conditions or of the efficiency of the management. The vaccine was restricted to calves under 30 days of age because the vaccination of older cattle, if infected, would tend to confuse the results and bring the vaccine into disrepute. Little attention was paid to the state of the vaccinal nodule, and in many cases revaccination of the herd was requested only when the disease occurred in an animal vaccinated as a calf some years previously. Animals in some herds received only one dose of vaccine, in other herds revaccination was carried out two to four times, at intervals varying from 16 to 24 months. There were no controls of the same age as the vaccinated animals. This omission was regrettable but efforts to persuade owners, already suffering heavy losses, to leave controls met with so much dissatisfaction and resistance that the idea was abandoned. The vaccine was judged on the comparative incidence of the disease in a herd *before* and *after* vaccination, the assessment being made at least seven years after the start of vaccination, that is when the animals had passed through the peak period of natural infection. This procedure may be open to criticism, but any weakness in it is diminished by the number of herds and the severity of the disease in them. It is believed that it has provided a practical basis of evaluation under the varying conditions that obtain in the field.

ASSESSMENT OF THE RESULTS OF THE FIELD TRIAL BASED ON A QUESTIONNAIRE

In 1953 when the trial had been in progress for seven years, a questionnaire was sent to 80 owners to obtain their views on vaccination. Sixty-three replies were received. Sixty owners were completely satisfied, two thought it too early to give an opinion and one was disappointed.

Thirty-two (50 per cent.) had no losses among vaccinated stock, and 28 reported that the disease had been either almost eliminated or that there had been a great reduction in losses. The question on losses in *unvaccinated* stock was not answered in every case. It would appear from the replies that in the five years *before* vaccination there had been a loss of 927 animals in 59 herds, and in 3½ years (mean period) *after* vaccination there had been a loss of 612 *unvaccinated* animals in 30 herds. In contrast with these figures the loss of *vaccinated* stock for seven years was 52 in 60 herds. In the herd which reported disappointing results the vaccinated calves were reared on bought-in cows of

unknown history and kept in communal pens under bad hygienic conditions. When these practices were discontinued the losses stopped. In another heavily infected herd which had good results for some years, there was recently a serious breakdown with a loss of nine animals in 12 months. This was caused through ignoring all recommendations and so allowing the build-up of gross infection.

In a contribution to a Symposium on Johne's Disease, Spears (1959) gave the results for 12 years in 110 herds (Table I). Eleven herds were discarded as insufficiently infected to provide an adequate test of the vaccine. There were no breakdowns among vaccinated stock in 61 herds and breakdowns occurred in 39. No material was received for laboratory examinations from a considerable number of animals reported as clinically suspicious and to overcome this complication suspected and confirmed cases have been added together in Table I.

TABLE I — RESULTS OF FIELD TRIALS OF VACCINE ON 110 HERDS FOR 12 YEARS (SPEARS, 1959)

Year	*No. of Herds*	*Total Vaccinated Stock*	*Total Un-vaccinated Stock*	*Total Stock*	*Cases of Johne's disease among :—*					
					Vaccinated Stock	*Per cent.*	*Un-vaccinated Stock*	*Per cent.*	*Total Stock*	*Per cent.*
1946	66	558	3,523	4,081	3	0·54	123	3·49	126	3·09
1947	82	1,504	4,637	6,141	1	0·07	167	3·60	168	2·74
1948	85	2,527	3,915	6,442	12	0·47	193	4·93	205	3·18
1949	90	3,527	4,274	7,801	3	0·09	195	4·56	198	2·54
1950	84	4,276	2,883	7,159	8	0·19	164	5·69	172	2·40
1951	80	4,821	2,163	6,984	19	0·39	114	5·27	133	1·90
1952	74	4,824	1,843	6,667	36	0·75	74	4·02	110	1·65
1953	64	5,320	1,277	6,599	27	0·51	40	3·13	67	1·02
1954	56	4,664	1,040	5,704	23	0·49	21	2·02	44	0·77
1955	54	4,790	1,053	5,825	17	0·35	18	1·71	35	0·60
1956	52	4,699	1,297	5,996	30	0·64	12	0·93	42	0·70
1957	47	4,381	909	5,290	11	0·25	4	0·44	15	0·28
					190		1,125		1,315	

It should be mentioned that owners or their veterinary surgeons were prompt in notifying clinical infection in vaccinated stock, but often failed to report infection in unvaccinated stock.

TUBERCULIN REACTIONS INDUCED BY VACCINATION

The vaccine sensitizes animals to both avian and mammalian tuberculins, so whether it can be safely used on tuberculosis-free herds without interfering unduly with routine tuberculin tests is a point of cardinal importance. It should not be used on tuberculous herds because of the risk of confusing the weak tuberculin reactions that frequently occur in chronic cases of tuberculosis with the reactions induced by the vaccine. Most of the trial herds were attested.

An analysis of 4,139 reactions to avian and mammalian tuberculins in vaccinated cattled showed that 85 per cent. gave greater reactions to avian tuberculin and 15 per cent. gave equal or slightly greater reactions to mammalian tuberculin ; the mean level of reactivity of all vaccinated animals was 10.18 mm. to avian and 6.08 mm. to mammalian (Hebert, Doyle and Paterson, 1959). Mammalian and avian tuberculin tests of vaccinated goats (Doyle, 1953) kept in isolation, showed that the mammalian reactions disappeared by the end of the second year whereas the avian were still pronounced at the end of the third year.

Provided it is known that an animal has been vaccinated, the interpretation of tests is not so difficult as was expected. For example, only three cases of tuberculosis occurred in 75 vaccinated herds in 11 years (average over the period) and these were characterized by severe mammalian reactions. As vaccination is undertaken only in tuberculosis-free herds, it would appear reasonable to postulate that should tuberculosis be inadvertently introduced into such a highly susceptible population, the mammalian reaction would be severe and sharply differentiated from the relatively weak reaction induced by vaccination. With the great progress which is being made in the eradication of tuberculosis the risk of it being re-introduced into herds is rapidly diminishing.

VACCINATION FAILURES

Rinjard (1934) claimed that he had never seen a vaccinated animal with acid-fast bacilli present in the nodule exhibit clinical symptoms. Our experience confirms that view. Most breakdowns in the trial occurred between the second and fifth year of age and can be attributed to the use of only one dose of vaccine or to an overlong interval between the first and second dose during which period protection waned or disappeared. Some breakdowns may have resulted from congenital infection, from contact-infection in early life in communal pens before protection was established or from rearing calves on infected nurse-cows.

VACCINATION AND THE CREATION OF CARRIERS

To determine whether vaccine confers complete protection or merely protects against clinical infection, faecal samples were cultured. The samples were collected from 20 cows and heifers which had been vaccinated for varying periods and each of which had been given two doses (30 mg.) of " modified " vaccine at an interval of one year.

A positive culture was obtained from one animal and then only one colony was present. When vaccination of this herd started, it was heavily infected and some of the original unvaccinated adult stock were still present when the faecal samples were taken, so there was ample opportunity for those vaccinated to contract infection. This evidence would suggest that vaccination does not create carriers or at least not in large numbers.

RECOMMENDATIONS FOR THE MANAGEMENT OF VACCINATED HERDS

The following recommendations based on experiences gained from this trial are made for herds that may be vaccinated in the future.

Clinical cases

Clinically affected animals should be immediately isolated and disposed of for slaughter. It was common practice in the trial herds—as indeed it is in many herds—to retain cows for considerable periods after the onset of symptoms, although owners were aware of the risks involved. The clinically affected cow is the principal source of infection. When there is any doubt as to an animal being infected, a complement-fixation test should be carried out as it is highly accurate for this purpose (Hole, 1956).

Bucket-feeding of calves

Calves should be bucket-fed and not be allowed to suck their dams because of the risk of infection from faeces on the udder. It is impossible to determine by visual examination whether an apparently normal cow is excreting *M. johnei* in the faeces. Udders should be washed thoroughly before taking milk for bucket feeding. The actual excretion of *M. johnei* in the milk would appear to be rare and probably occurs only in advanced clinical cases (Doyle, 1954).

Foetal infection

As it is now clear that foetal infection occurs (Alexejeff-Goloff, 1926, Lawrence, 1955) the calves of clinically affected cows or of cows that develop symptoms within a short time of calving, should not be retained in the herd.

Separate calf pens

Infected calves can transmit the disease to healthy in-contacts, so communal pens should if possible be avoided. A separate pen should be provided for each calf, a practice that should be adopted irrespective of Johne's disease.

DISCUSSION OF THE RESULTS OF VACCINATION WITH THE STANDARD VACCINE

The questionnaire sent to owners in 1953 showed that during the first eight years of the trial no losses occurred among vaccinated stock in 50 per cent. of the herds, in spite of the fact that these herds were heavily infected and that the unvaccinated stock were retained until the end of their economic life. In 1957, the records show that no breakdowns occurred over a period of twelve years in 61 of 99 herds. The owners reported that in the remaining herds the number of clinical cases had been greatly reduced.

Rinjard (1934) reported that vaccination gave complete protection in 133 herds comprising 5,650 animals, and good, but incomplete, protection in 20 herds comprising 800 animals. He stated that it eliminated clinical cases in 8 herds out of every 10 and brought about a considerable reduction in the others.

With a few exceptions, owners were completely satisfied and appreciative of the results which, in many instances, were obtained in spite of neglecting elementary precautions. Many owners did not dispose of clinical cases until they became debilitated, although they knew it was economically unsound to retain them and that they were a serious source of infection for other stock.

Revaccination, which is essential, was frequently omitted in the early years of the trial and in other cases there was often an interval of three to four years between the first and second inoculation. In herds supervised by this laboratory, the disease has been controlled without difficulty.

The tuberculin reaction induced by the vaccine is the principal obstacle to its more general use, but is not so serious as has sometimes been suggested.

The large number of tests of the trial herds proved there is little difficulty in interpreting reactions, provided it is known that vaccine has been used. Having regard to the incidence and wide distribution of the disease, and the difficulties involved in the diagnosis of preclinical infection, vaccination would appear to be the most practical and efficient method of control in heavily infected herds. When used in conjunction with a few simple but essential measures, it appears to be relatively easy to eliminate clinical disease from the average self-contained dairy herd by vaccination ; it may even be that the disease is eradicated from these herds.

TABLE II—RESULTS OF A FIELD TRIAL OF THE MODIFIED VACCINES.

Herd Number	*Breed*	*Losses in 5 years before entering trial*	*Losses in 5 years after entering trial*	
			Vaccinated	*Unvaccinated*
1	*Ayrshire*	19	Nil	18
2	*Jersey*	20	Nil	4
3	*Jersey*	14	Nil	6

A further trial is now in progress in which one-quarter of the animals are being vaccinated once only, one-quarter revaccinated regularly and one-half retained as unvaccinated controls. A comparison is being made of the clinical disease, the degree of faecal excretion and the interference with the tuberculin test which develops in each group.

A MODIFIED VACCINE AND ITS FIELD TRIAL

This vaccine was evolved with the object of eliminating the nodule at the site of injection and of permitting revaccination at regular intervals without the risk of abscess formation. It contains the same strains of *M. johnei* as the standard vaccine, but the excipient consists of a mixture of equal parts of castor oil and camphorated oil, with 7.5 mg/ml. of moist-dried culture. The dose is 2 ml. subcutaneously. Increasing the weight of bacilli per ml. in the

standard vaccine appears to increase the size of the nodule whereas in the modified vaccine it has been increased to three times without any untoward result. The modified vaccine has been submitted to safety and antigenicity tests on goats over a period of years at Weybridge, and has proved satisfactory. Goats are useful for preliminary work, but results must be confirmed on cattle against natural infection under field conditions. The vaccine has therefore been tested on three heavily infected herds; on two for seven years, and on one for five years. Calves were vaccinated within 30 days of birth and re-vaccinated at 12 months of age. This appears to have been sufficient to eradicate clinical disease (Table II).

The effect of the vaccine on tuberculin reactions is similar to that of standard vaccine. Apart from the minor disadvantage of requiring more culture, it would appear to be an improvement on the standard vaccine in not producing a nodule, allowing revaccination at regular intervals, and in that the larger dose of bacilli seems to confer a stronger and possibly a more durable immunity.

ACKNOWLEDGEMENTS

To Mr. H. N. Spears, for preparing the vaccine, keeping the records and compiling the annual reports.

To Mr. W. D. Macrae, for his assistance in selecting suitable herds for the trial.

To Mr. P. Stuart, for culturing the faecal samples.

To the veterinary surgeons and the Ministry's veterinary officers who took part in the trial and without whose co-operation it could not have been carried out.

To Mr. R. Martin for much technical assistance.

REFERENCES

ALEXEJEFF-GOLOFF, N. A. (1929) : *Z. infekt. Krank. Haustiere*, **36**, 313.
DOYLE, T. M. (1953) : *Brit. vet. J.*, **109**, 275.
(1954) : *Ibid.*, **110**, 215.
(1956) : *Proc. O.E.E.C. Seminar Johne's Disease*, Weybridge.
HEBERT, C. N. & PATERSON, A. B. (1955) : *Vet. Rec.*, **67**, 1143.
HEBERT, C. N., DOYLE, T. M. & PATERSON, A. B. (1959) : *Ibid.*, **71**, 108.
HOLE, N. H. (1956) : *Proc. O.E.E.C. Seminar Johne's Disease*, Weybridge.
LARSEN, A. B. & VARDAMAN, T. H. (1959) : *Proc. 62nd U.S. Livestock San. Ass.*, 163.
LAURENCE, W. E. (1956): *Proc. O.E.E.C. Seminar Johne's Disease*, Weybridge.
M'FADYEAN, J. & SHEATHER, A. L. (1916) : *J. comp. Path.*, **29**, 62.
MINETT, F. C. (1933) : *Vet. Rec.*, **13**, 1074.
RINJARD, M. P. (1934) : *Bull. off. int. Epizoot.*, **8**, 326.
SIGURDSSON, B. (1956) : *Proc. O.E.E.C. Seminar Johne's Disease*, Weybridge.
(1960) : *Amer. J. Vet. Res.*, **21**, 54.
SIKES, D. & GROTH, A. (1950) : *Amer. J. vet. Res.*, **11**, 181.
SMITH, H. W. (1954) : *J. Path. Bact.*, **68**, 367.
SPEARS, H. N. (1959) : *Vet. Rec.*, **71**, 1154.
TAYLOR, A. W. (1949) : *Vet. Rec.*, **61**, 539.
(1950) : *J. Path. Bact.*, **62**, 647.
TWORT, F. W. & INGRAM, G. R. (1913) : *A Monograph on Johne's Disease*, London.
VALLÉE, H. (1924) : *C.R. Acad. Sci. (Paris)*, Jan. 2nd, **152**.
VALLÉE, H., RINJARD, P. & VALLEE, M. (1934) : *Rev. gen. Med.*, **43**, 777.
(1941) : *Bull. Acad. Med.*, **125**, 195.

(Received for publication 22 June, 1960)

THE USE OF THE HAEMAGGLUTINATION TECHNIQUE FOR THE DETECTION OF ANTIBODIES IN GASTRO-INTESTINAL NEMATODE INFECTIONS OF SHEEP*

By E. J. L. Soulsby

Department of Animal Pathology, University of Cambridge

I. THE TANNED RED CELL TECHNIQUE

The tanned red cell agglutination technique of Boyden (1951) is in wide use as a means of detecting antibody in a variety of circumstances. In the field of helminth infections Kagan and Bargai (1956) used it to detect antibodies to *Trichinella spiralis* in experimentally infected rabbits and Kagan (1958) also used it to study the specificity of artificially produced antisera to various ascarids. In the field of what might be designated resistance to helminths as opposed to the pure serological study of antigens and antibodies, Soulsby (1956, 1957) has used the technique to follow the seasonal antibody levels in a flock of sheep undergoing the spring rise phenomenon. During these investigations it was found that while the same general trends were indicated by the haemagglutination test and the complement fixation test there was no constant relationship between the two tests. It was suggested that the haemagglutination test might be measuring incomplete antibodies but Coombs and Fiset (1954) have shown that such a system could not detect incomplete antibodies.

It has been possible to carry out more extensive investigations into the haemagglutination reaction using sheep infected with either *Haemonchus contortus* or *Trichostrongylus* spp. and this communication gives details of some of these investigations.

MATERIALS AND METHODS

Antigens. As a routine antigen for the complement fixation techniques the heated *H. contortus* larval antigen of Stewart (1950*a*) was used. This was prepared by grinding in 25 ml. of glass-distilled water and in a bacterial mill 1 g. of third-stage *H. contortus* larvae. The emulsion was heated for ten

* This work was carried out while the author held an Ian McMaster Fellowship at the Commonwealth Scientific and Industrial Research Organization's McMaster Animal Health Laboratory, Sydney, Australia.

minutes in a brine bath and after cooling and centrifuging was made isotonic with sodium chloride. For the haemagglutination tests this antigen was generally used in an unheated form. Several other antigens were used and details will be mentioned where applicable.

Antisera. These were obtained from sheep infected with either *H. contortus* or *Trichostrongylus* spp., from worm-free lambs (except *Strongyloides*) and from newly-born lambs. All sera were stored at —20° C until required. Before use they were inactivated at 56° C for 30 minutes, and for use in the haemagglutination test were absorbed at a 1 in 10 dilution with 1/5th volume of three times washed, packed sheep red cells.

Complement fixation test. The method described by Stewart (1950*a*) was followed except that veronal buffer (Mayer, Osler & Heidelberger, 1946) was used as the diluent.

Haemagglutination test. In general the technique followed the procedure detailed by Boyden (1951) and Soulsby (1956). Commercial tannic acid was used in a dilution of 1 in 20,000 in veronal buffer at pH 7.2, made up freshly each day. Parenthetically it can be stated that the use of veronal buffer obviated the use of various buffered solutions described by Boyden and all manipulations were carried out using veronal buffer at pH 7.2. As a diluent for serum and a washing agent for antigen-coated tanned cells a 1 in 250 dilution of guinea pig serum in veronal buffer was used. This was necessary since the antigen caused some degree of agglutination of tanned red cells and dilute guinea pig serum exerted a " protective " effect and allowed a stable suspension of cells to be produced. Sheep erythrocytes were preserved in Alsever's solution, being washed three times before use. A 3 per cent. suspension of cells was used in the test.

As a routine a 1 in 5 dilution of unheated *H. contortus* larval antigen was adsorbed on to tanned cells, but other antigen preparations such as the heated antigen, as used in the complement fixation test, the metabolic products of third stage *H. contortus* larvae, and the exsheathing fluid of such larvae, were also used. Metabolic products were obtained by incubating approximately 1 g. of exsheathed *H. contortus* infective larvae in saline at room temperature for 24 hours. Exsheathing fluid (Rogers & Sommerville, 1957) was supplied by Mr. R. I. Sommerville.

Dilutions of list sera in 0.5 ml. quantities were made in the concavities of M.R.C. perspex agglutination plates, adequate controls being set up with each set of tests. Two drops of sensitized erythrocytes (approximately 0.125 ml.) from a Pasteur pipette were added to each serum dilution and mixed. The plates were left at room temperature for two hours, after which the degree of haemagglutination was recorded.

It must be stressed that it was essential for the various stages of treatment to be carried out accurately and as a continuous process, so that all batches of sensitized cells had undergone identical periods of incubation and treatment, otherwise a variation of the final titre with individual sera resulted.

Absorption tests. Apart from the routine absorption of sera with packed sheep cells to remove unwanted isophile antibodies some absorption tests were

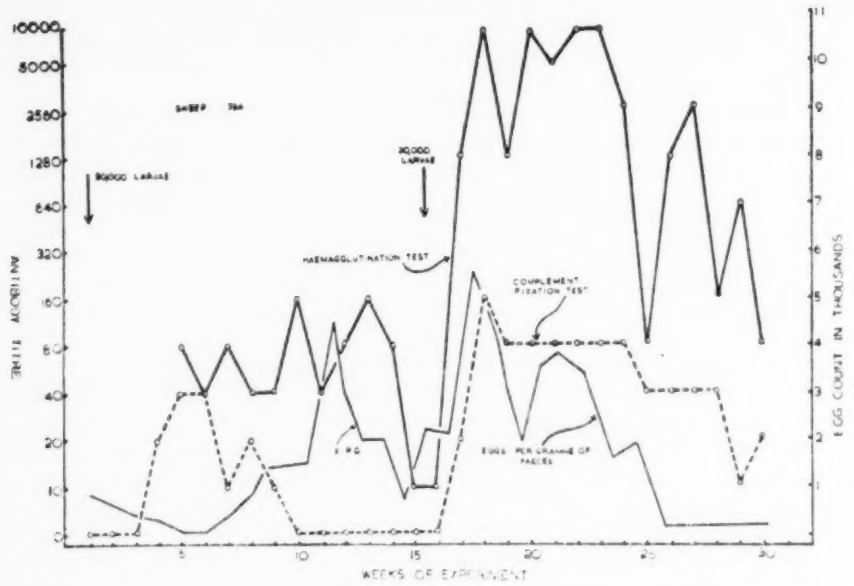


FIG. 1.—Haemagglutination and complement fixation antibody titres in Sheep 746 infected with *H. contortus*.

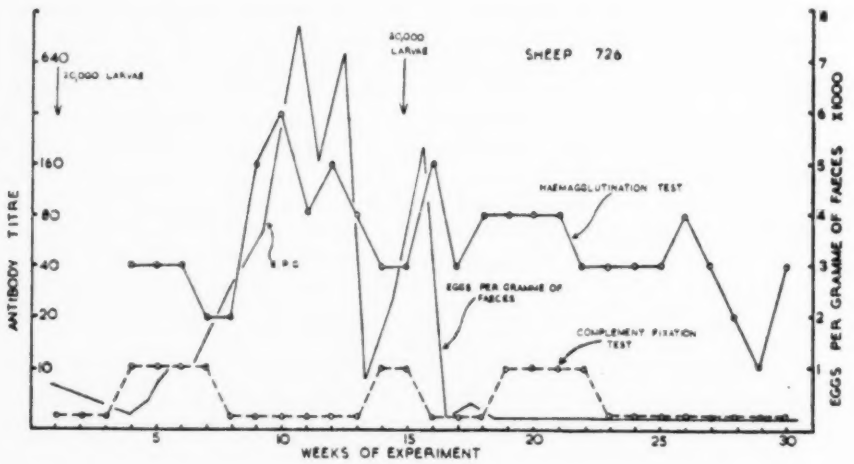


FIG. 2.—Haemagglutination and complement fixation antibody titres in Sheep 726 infected with *H. contortus*.

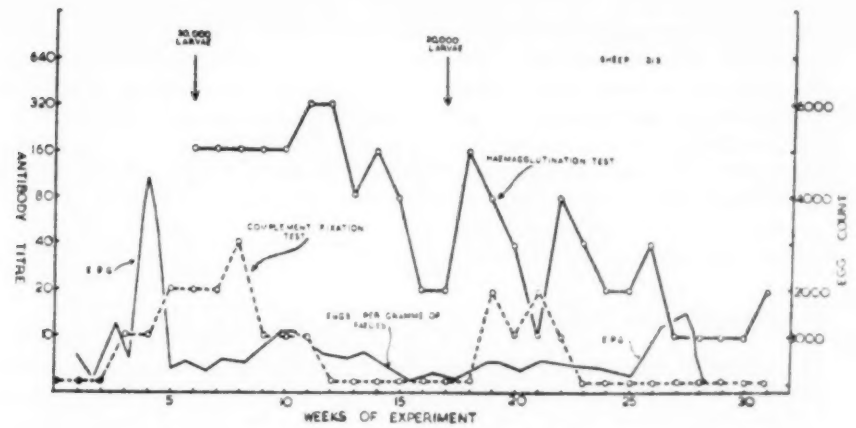


FIG. 3.—Haemagglutination and complement fixation antibody titres in Sheep 213 infected with *Trichostrongylus* spp.

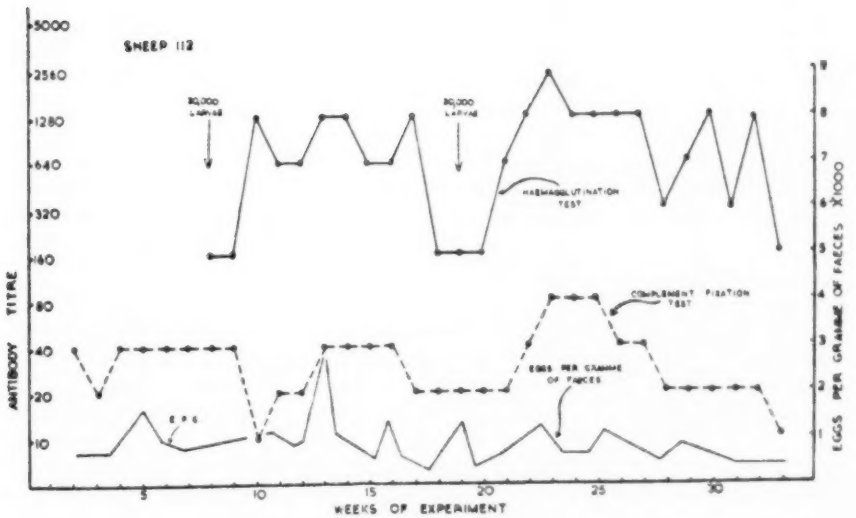


FIG. 4.—Haemagglutination and complement fixation antibody titres in Sheep 112 infected with *Trichostrongylus* spp.

carried out to remove haemagglutinating antibody. When this was done each serum sample was divided into four aliquots and treated as follows. One sample was not absorbed. One was absorbed with 1/5th volume of packed untreated red cells, one was absorbed with 1/5th volume of packed tanned red cells but without antigen and the final aliquot was absorbed with 1/5th volume of packed tanned red cells which had been treated with antigen. These absorptions were carried out up to three times on certain sera. After absorption the sera were recovered by centrifugation and subjected to the haemagglutination and the complement fixation tests.

RESULTS

Relationship between Haemagglutination titres and complement fixation titres

As previously mentioned it has been found (Soulsby, 1956) that no constant relation existed between these two tests. Figs. 1, 2, 3 and 4 illustrate these relationships in four sheep, two of which were infected with *H. contortus* (Figs.

TABLE I—HAEMAGGLUTINATION AND COMPLEMENT FIXATION TEST RESULTS WITH ABSORBED SERA

Absorbed with	*Serum*	*Times absorbed*	*Haemagglutination titre after absorptions*	*Complement fixation titre after absorption*
a	764	2	—	1/80
b	764	2	2,560	1/80
c	764	2	2,560	1/80
a	781	2	—	1/20
b	781	2	80	1/20
c	781	2	80	1/40
a	735	2	20	1/10
b	735	2	320	1/10
c	735	2	640	1/40
a	764	3	20	1/40
b	764	3	5,000	1/40
c	764	3	5,000	1/80
a	745	2	—	1/10
b	745	2	160	1/10
c	745	2	320	1/20
a	112	2	—	1/40
b	112	2	160	1/80
c	112	2	160	1/80
a	121	2	—	1/20
b	121	2	320	1/20
c	121	2	640	1/20

a — Tanned cells coated with unheated antigen.
b — Tanned cells without antigen.
c — Normal cells.

1 and 2) and two of which were infected with *Trichostrongylus* spp. (Figs. 3 and 4) over a period of 31 weeks.

It can be seen that there is not a constant relationship between the complement fixation and the haemagglutination tests. There are times, particularly after the administration of larvae, when both the complement fixation and the haemagglutination techniques show comparable trends, but there are also periods when there is almost an inverse relationship between the two tests. In view of this it was felt that during these periods of apparent inverse relationship the two tests were measuring different antibodies ; consequently absorption tests were carried out to see whether the complement fixation antibody could be differentiated from the antibody responsible for haemagglutination.

The sera were diluted 1 in 10 in veronal buffer and were there absorbed (as detailed above) with the following packed cells.

(*a*). Tanned and coated with unheated antigen.
(*b*). Tanned only.
(*c*). Untreated cells.

Two of these absorptions were carried out and the absorbed sera were then tested for haemagglutination and complement fixation antibodies. The results of this are presented in Table I.

It will be seen from these absorption tests that it was possible to absorb the haemagglutinating activity out completely in many cases and to leave a substantial although somewhat reduced complement fixation titre. Reduction in complement fixation titre also occurs with the use of tanned cells alone but this might be anticipated since tanned cells absorb protein and in doing so may well remove antibody protein. This fact is also applicable to the tanned cells coated with antigen but it is obvious from the results that a specific removal of the haemagglutinating antibody has occurred with the use of the antigen-coated cells.

Since a heated *H. contortus* antigen was used in the complement fixation tests as against the unheated antigen in the haemagglutination tests further absorptions were carried out using cells coated with unheated antigen and cells coated with heated antigen. The results of these absorptions are presented in Table II.

From these results it can be seen that it has again been possible to show differential absorption of haemagglutinins, the heated antigen being slightly more efficient for this than the unheated antigen. However, the heated antigen did not increase the absorption of the complement fixation antibodies and it must be concluded that even with the heated antigen the antibodies responsible for haemagglutination are distinct from those causing complement fixation.

Mention has been made of the fact that there are times when there is a correlation between the haemagglutination and the complement fixation tests and others when there is an inverse relationship. It is possible to explain this on the theoretical basis that when there is a direct relationship between the two titres, the haemagglutinating system is indicating an antibody response

TABLE II—ABSORPTION TESTS ON SELECTED SERA USING RED CELLS TREATED WITH HEATED OR UNHEATED *H. contortus* ANTIGEN

Absorbed with	*Serum*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*			
			1/5	1/10	1/20	1/40
a	112	1,280	+++	+++	+++	++
b	112	1,280	+++	+++	+++	++
c	112	1,280	+++	+++	+++	++
a	206	40	++	+	±	−
b	206	0	++	+	±	−
c	206	320	+++	++	+	±
a	182	40	+++	+++	+++	++
b	182	0	+++	+++	+++	++
c	182	160	+++	+++	+++	++
a	206	10	++	+	−	−
b	206	0	++	+	±	−
c	206	80	++	+	±	−
a	90	80	++	+	±	−
b	90	80	++	+	±	−
c	90	320	+++	+	±	−
a	192	80	+++	+++	++	+
b	192	80	+++	+++	++	+
c	192	1,280	+++	+++	++	+
a	116	20	++	+	±	−
b	116	20	++	+	±	−
c	116	160	+++	++	+	±
a	172	20	+++	+++	++	+
b	172	10	+++	+++	++	+
c	172	160	+++	+++	++	+
a	781	20	+	±	−	−
b	781	0	+	±	−	−
c	781	80	++	+	±	−
a	786	80	++	+	±	−
b	786	40	++	+	±	−
c	786	160	++	+	±	−
a	745	1,280	+++	++	+	±
b	745	1,280	+++	++	+	±
c	745	1,280	+++	+++	++	+
a	112	1,280	+++	+++	++	+
b	112	1,280	+++	+++	++	+
c	112	1,280	+++	+++	++	+
a	149	80	+++	++	+	±
b	149	20	+++	++	+	±
c	149	320	+++	+++	++	+
a	735	80	++	+	±	−
b	735	160	++	+	±	−
c	735	1,280	+++	++	+	±
a	339	40	+++	++	+	±
b	339	20	+++	++	+	±
c	339	160	+++	+++	++	+

TABLE II (CONT.)

Absorbed with	*Serum*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*			
			1/5	1/10	1/20	1/40
a	372	80	+	±	−	−
b	372	80	+	±	−	−
c	372	160	++	±	−	−
a	929	80	++	+	±	−
b	929	80	++	+	±	−
c	929	320	+++	++	+	±
a	781	0	+	±	−	−
b	781	0	+	±	−	−
c	781	160	++	±	−	−
a	192	20	−	−	−	−
b	192	0	−	−	−	−
c	192	160	±	−	−	−
a	764	1,280	+++	+++	+++	+++
b	764	1,280	+++	+++	+++	+++
c	764	1,280	+++	+++	+++	+++

a — Tanned cells coated with unheated antigen.
b — Tanned cells coated with heated antigen.
c — Untreated cells.

directly related to resistances and that this is also detected by the complement fixation system. Both tests may in fact be reacting to the same antibody complex. It is of note that when the complement fixation reaction is strong it is more difficult to remove the haemagglutinin by absorption (see Table II). When there is an inverse relationship it can be suggested that different antibody systems are concerned, which are not detected by the complement fixation system. In order to assess this possible explanation two groups of sera were selected, one group where the haemagglutination and the complement fixation techniques showed a direct relationship and the other where there was an inverse relationship. It was envisaged that if the theoretical basis suggested was true then the absorption of the sera showing a direct relationship would result in the complement fixation titre being more markedly affected than in the series where an inverse relationship occurred—in fact in the latter it should be affected minimally since it is considered to belong to a different antibody system. The results of such absorptions are presented in Table III.

From these results it can be seen that while not all sera behaved in the manner anticipated there is some indication that where a direct relationship exists the complement fixation titre is more markedly affected than where there is an inverse relationship.

Since some degree of differential absorption occurred between the heated and the unheated antigen (see Table II) a series of sera was examined to see whether these two antigens would give comparable results in the haemagglutination test. Fig. 5 shows the results of such tests and demonstrates that there

TABLE II—ABSORPTION TESTS ON SELECTED SERA USING RED CELLS TREATED WITH HEATED OR UNHEATED *H. contortus* ANTIGEN

Absorbed with	*Serum*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*			
			1/5	1/10	1/20	1/40
a	112	1,280	+++	+++	+++	++
b	112	1,280	+++	+++	+++	++
c	112	1,280	+++	+++	+++	++
a	206	40	++	+	±	−
b	206	0	++	+	±	−
c	206	320	+++	++	+	±
a	182	40	+++	+++	+++	++
b	182	0	+++	+++	+++	++
c	182	160	+++	+++	+++	++
a	206	10	++	+	−	−
b	206	0	++	+	±	−
c	206	80	++	+	±	−
a	90	80	++	+	±	−
b	90	80	++	+	±	−
c	90	320	+++	+	±	−
a	192	80	+++	+++	++	+
b	192	80	+++	+++	++	+
c	192	1,280	+++	+++	++	+
a	116	20	++	+	±	−
b	116	20	++	+	±	−
c	116	160	+++	++	+	±
a	172	20	+++	+++	++	+
b	172	10	+++	+++	++	+
c	172	160	+++	+++	++	+
a	781	20	+	±	−	−
b	781	0	+	±	−	−
c	781	80	++	+	±	−
a	786	80	++	+	±	−
b	786	40	++	+	±	−
c	786	160	++	+	±	−
a	745	1,280	+++	++	+	±
b	745	1,280	+++	++	+	±
c	745	1,280	+++	+++	++	+
a	112	1,280	+++	+++	++	+
b	112	1,280	+++	+++	++	+
c	112	1,280	+++	+++	++	+
a	149	80	+++	++	+	±
b	149	20	+++	++	+	±
c	149	320	+++	+++	++	+
a	735	80	++	+	±	−
b	735	160	++	+	±	−
c	735	1,280	+++	++	+	±
a	339	40	+++	++	+	±
b	339	20	+++	++	+	±
c	339	160	+++	+++	++	+

TABLE II (CONT.)

Absorbed with	*Serum*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*			
			1/5	1/10	1/20	1/40
a	372	80	+	±	−	−
b	372	80	+	±	−	−
c	372	160	++	±	−	−
a	929	80	++	+	±	−
b	929	80	++	+	±	−
c	929	320	+++	++	+	±
a	781	0	+	±	−	−
b	781	0	+	±	−	−
c	781	160	++	±	−	−
a	192	20	−	−	−	−
b	192	0	−	−	−	−
c	192	160	±	−	−	−
a	764	1,280	+++	+++	+++	+++
b	764	1,280	+++	+++	+++	+++
c	764	1,280	+++	+++	+++	+++

a — Tanned cells coated with unheated antigen.
b — Tanned cells coated with heated antigen.
c — Untreated cells.

directly related to resistances and that this is also detected by the complement fixation system. Both tests may in fact be reacting to the same antibody complex. It is of note that when the complement fixation reaction is strong it is more difficult to remove the haemagglutinin by absorption (see Table II). When there is an inverse relationship it can be suggested that different antibody systems are concerned, which are not detected by the complement fixation system. In order to assess this possible explanation two groups of sera were selected, one group where the haemagglutination and the complement fixation techniques showed a direct relationship and the other where there was an inverse relationship. It was envisaged that if the theoretical basis suggested was true then the absorption of the sera showing a direct relationship would result in the complement fixation titre being more markedly affected than in the series where an inverse relationship occurred—in fact in the latter it should be affected minimally since it is considered to belong to a different antibody system. The results of such absorptions are presented in Table III.

From these results it can be seen that while not all sera behaved in the manner anticipated there is some indication that where a direct relationship exists the complement fixation titre is more markedly affected than where there is an inverse relationship.

Since some degree of differential absorption occurred between the heated and the unheated antigen (see Table II) a series of sera was examined to see whether these two antigens would give comparable results in the haemagglutination test. Fig. 5 shows the results of such tests and demonstrates that there

TABLE III—ABSORPTION OF SERA SHOWING DIRECT OR INVERSE RELATIONSHIPS BETWEEN HAEMAGGLUTINATION AND COMPLEMENT FIXATION TESTS. ABSORBED WITH EITHER HEATED OR UNHEATED *H. contortus* ANTIGEN

Serum	*Absorbed with*	*Relationship between tests*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*				*Opinion whether theory in text is upheld by result*
				1/5	1/10	1/20	1/40	
112	a	Indirect	1,280	+++	+++	+++	++	No
	b		1,280	+++	+++	+++	++	
	c		1,280	+++	+++	+++	+	
	d		1,280	+++	+++	+++	++	
206	a	Indirect	320	+++	++	+	±	Inconcluive
	b		320	+++	++	+	±	
	c		0	++	+	±	−	
	d		4	++	+	±	−	
182	a	Direct	160	+++	+++	+++	++	No
	b		160	+++	+++	+++	++	
	c		0	+++	+++	+++	++	
	d		40	+++	+++	+++	++	
206	a	Indirect	80	++	+	±	−	Yes
	b		80	++	+	±	−	
	c		0	++	+	±	−	
	d		10	++	+	−	−	
90	a	Indirect	160	++	+	±	−	Yes
	b		320	+++	+	±	−	
	c		80	++	+	±	−	
	d		80	++	+	±	−	
192	a	Indirect	1,280	+++	+++	++	+	Yes
	b		1,280	+++	+++	++	+	
	c		160	+++	+++	++	+	
	d		160	+++	+++	++	+	
116	a	Direct	160	+++	++	+	±	Yes—at least suggestive
	b		160	+++	++	+	±	
	c		20	++	±	±	−	
	d		20	++	±	−	−	
172	a	Direct	160	+++	+++	++	+	No
	b		160	+++	+++	++	+	
	c		10	+++	+++	++	+	
	d		20	+++	+++	++	+	
781	a	Direct	80	++	+	±	−	Yes
	b		80	++	+	±	−	
	c		0	+	±	−	−	
	d		20	+	±	+	−	
786	a	Indirect	160	++	+	±	−	Yes
	b		160	++	+	±	−	
	c		40	++	+	±	−	
	d		40	++	+	±	−	
745	a	Indirect	1,280	+++	+++	++	+	No
	b		1,280	+++	+++	++	+	
	c		1,280	+++	++	+	±	
	d		1,280	+++	++	+	±	

TABLE III (CONT.)

Serum	*Adsorbed with*	*Relationship between tests*	*Haemagglutination titre after absorption*	*Complement fixation titre after absorption*				*Opinion whether theory in text is upheld by result*
				1/5	1/10	1/20	1/40	
112	a	Direct	1,280	+++	+++	++	+	No
	b		1,280	+++	+++	++	+	
	c		1,280	+++	+++	++	+	
	d		1,280	+++	+++	++	+	
149	a	Direct	320	+++	+++	++	+	Yes
	b		320	+++	++	++	+	
	c		20	++	+	±	±	
	d		80	++	+	+	−	
735	a	Direct	1,280	+++	++	+	±	Yes
	b		1,280	+++	++	+	±	
	c		160	++	±	−	−	
	d		80	++	+	−	−	
5[illegible]	a	Indirect	160	+++	+++	++	+	Yes
	b		160	+++	+++	++	+	
	c		20	+++	+++	+	±	
	d		40	+++	+++	+	−	
372	a	Indirect	160	++	±	−	−	Yes
	b		160	++	±	−	−	
	c		80	++	±	−	−	
	d		80	++	±	−	−	
929	a	Direct	320	+++	++	+	±	Yes
	b		320	+++	++	+	±	
	c		80	++	±	−	−	
	d		80	++	+	−	−	
781	a	Direct	160	++	±	−	−	
	b		160	++	±	−	−	
	c		0	+	−	−	−	
	d		0	+	−	−	−	
192	a	Indirect	160	±	−	−	−	Inconclusive (No)
	b		160	±	−	−	−	
	c		0	−	−	−	−	
	d		20	−	−	−	−	
764	a	Direct	1,280	+++	+++	+++	+++	No
	b		1,280	+++	+++	+++	+++	
	c		1,280	+++	+++	+++	+++	
	d		1,280	+++	+++	+++	+++	

a — Not absorbed.
b — Absorbed with untreated cells.
c — Absorbed with tanned cells coated with heated antigen.
d — Absorbed with tanned cells coated with unheated antigen.
All sera absorbed once only.

is no constant relationship between haemagglutination titres when the heated antigen and the unheated antigen are used in parallel tests. Possibly the results with the unheated antigen follow the complement fixation better than do those with the heated antigen.

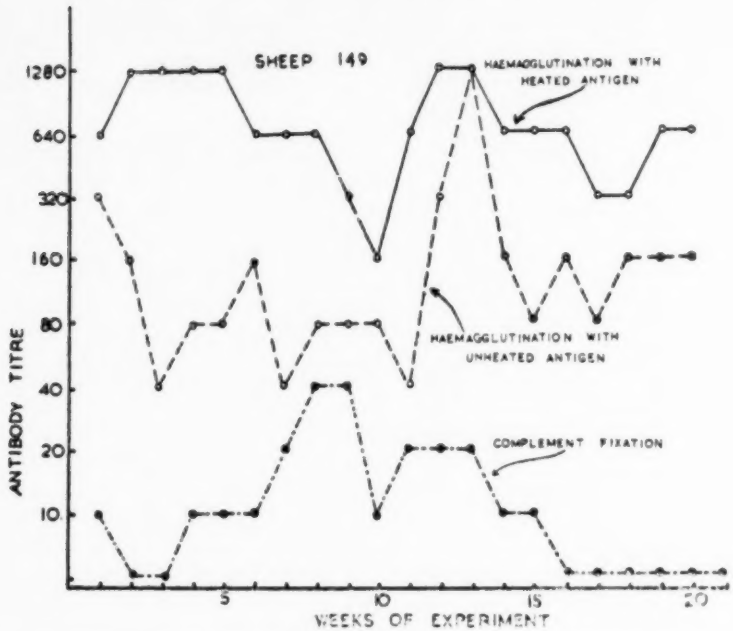


FIG. 5.—Comparison of haemagglutination tests using heated and unheated antigen of *H. contortus* and the complement fixation test in Sheep 149 infected with *Trichostrongylus* spp.

Previous publications on immunity to parasites have stressed the importance of the " metabolic products " of the organisms as immunizing agents (Thorson, 1951, Chandler, 1953), and recently Soulsby, Sommerville and Stewart (1959) and Soulsby and Stewart (1960) have demonstrated that exsheathing fluid, or some substance closely related to it, is an important antigen, particularly in the self-cure mechanism in *H. contortus* infection. Haemagglutination tests were set up using these antigens. Limited quantities of metabolic products and exsheathing fluid were available and consequently serial bleedings could not be examined, but the results of tests on selected sera are presented in Table IV.

It will be seen that both the " metabolic products " and the exsheathing fluid can serve as antigens in the haemagglutination test and they appear to follow the titres obtained with the unheated antigen ; whether this would be the case when there was a marked serological reaction after reinfection is open to conjecture.

DISCUSSION

Using the haemagglutination technique and a *H. contortus* antigen it has been possible to demonstrate an antibody response in sheep infected with either *H. contortus* or *Trichostrongylus* spp. This cross-reaction is not unexpected since

TABLE IV—HAEMAGGLUTIATION TESTS ON SELECTED SERA USING "METABOLIC PRODUCTS" AND EXSHEATHING FLUID AS ANTIGENS

Serum and date	*Titre with unheated antigen*	*Titre with metabolic products*	*Serum and date*	*Titre with unheated antigen*	*Titre with exsheathing fluid*
781 19—5	80	160	735 19—5	1,280	640
781 26—5	80	160	735 26—5	1,280	640
781 2—6	160	160	735 2—6	1,280	640
781 9—6	320	320	735 9—6	1,280	640
781 17—6	160	160	735 17—6	320	320
781 23—6	160	160	735 23—6	1,280	640
781 30—6	160	160	735 30—6	1,280	640

a *H. contortus* antigen can be used to detect antibodies by the complement fixation technique in *Trichostrongylus* spp. infection in sheep (see Stewart, 1950*b*). A more detailed analysis of the antibody response and antigen analysis will be given elsewhere.

It is difficult to assess the significance of the haemagglutination reaction. There can be little doubt that it is some kind of a measure of the antibody response and also of the immune status of the animal. Absorption tests have demonstrated that antibodies detected by it are to a great extent distinct from antibodies detected by the complement fixation technique. When the two tests are compared it is seen that following stimulation by larvae there is a reasonable degree of correlation between the titres and in many cases there is a much more marked and rapid response on the part of the haemagglutination reaction. This is to be expected to some extent since the test is able to detect smaller amounts of antibody than the complement fixation test. At such points of an infection it would appear that both the haemagglutination and the complement fixation test results were of reaction to a comparable set of antibodies. Some degree of support, but not unequivocal support, is given to this by the fact that absorption tests on sera at this time tend to remove more complement-fixing antibody than when similar tests are carried out on sera showing an inverse relationship between the haemagglutination and complement fixation tests. There are many periods when the haemagglutination titres are frankly inversely related to the complement fixation titres and often a progressive rise in haemagglutination titre precedes a period of increased egg output on the part of the parasite. This latter activity could be explained on the basis that the haemagglutination test is reacting to antibodies stimulated by such materials as exsheathing fluid and metabolic products, and it has been shown that both these substances behave in a manner similar

to the unheated antigen. Frequently a depression of the antibody measured by the complement fixation test is associated with an increase in egg-count (see also Stewart, 1950*b*, *c*), and this can be construed as an increase in parasitic activity and development. A rise in haemagglutination titre at such times might be a measure of antibodies which are *not at that time* concerned with the protection of the animal and may in fact be a reflection of the activity of the parasite.

In considering the haemagglutination tests from a general point of view it must be remembered that it is not known at present how many or what antigens are being absorbed onto the tanned cells. It has been shown by agar-diffusion-precipitin tests (Soulsby & Stewart, 1960) that at least four antigenic components occur in the *H. contortus* antigen and also that several different antibodies can be present which show marked quantitative and qualitative variation during an infection. In other parasitic infections such as *Ascaris suum* it can be shown that a wide variety of antibodies are raised by infection, including not only antibodies against parasitic tissues but also such antibodies as these against blood group substance (Soulsby & Coombs, 1959) and heterophile substances (Soulsby, 1958). It is to be anticipated that the response to *H. contortus* and *Trichostrongylus* spp. infection is no less complex. Some indication that this is so is given by the fact that titres with heated antigen vary from those obtained with an unheated antigen. In fact it is anticipated that during the course of an infection in sheep with either *H. contortus* or *Trichostrongylus* spp. the immune response is even more variable than has so far been observed (see Soulsby, 1960), and that the immune sera contains several, possibly many, variable antibodies each with its own particular specificity. Haemagglutination, by virtue of its greater sensitivity, may well be able to detect variations in the levels of each system more adequately than other tests and, depending on the antigen preparation used, a certain response will be delineated which may bear little relationship to either the sum of the response of all the antibodies present or to another single antibody in the general system. It is reasonably clear that when one is using haemagglutination tests, particularly in nematode infections, the choice of antigen is important and any assessment of the results can apply only to the antigen in question.

Further understanding of the haemagglutination tests must await detailed study of the antigens, particularly using fractionation techniques.

SUMMARY

Sera taken during the course of infection of sheep with *H. contortus* or *Trichostrongylus* spp. were examined by the haemagglutination and complement fixation techniques. No constant relationship was observed between the antibody levels indicated by these two techniques. Absorption tests indicated that generally the haemagglutinating antibody was distinct from that measured by complement fixation. Not only did the haemagglutination reaction differ from the complement fixation but different antigens, when used for haemagglutination, showed different responses. The significance of these results is discussed.

A drug of

remarkable versatility

Introduced as the pioneer phenothiazine sedative but now established in other fields and still widening its scope.

DETAILED INFORMATION IS AVAILABLE ON REQUEST

AN **M&B** BRAND VETERINARY PRODUCT.

VA 1253

SAVE time
SAVE waste
SAVE sheep
WITH

AEROSOL CHLOROMYCETIN TINCTURE

Contagious Foot Rot is still a menace to sheep health, preventing successful flock management and causing great financial loss to the breeder.

Aerosol Chloromycetin* Tincture eliminates foot rot quickly and economically — the great majority of cases require only a single application.

AEROSOL CHLOROMYCETIN TINCTURE

for quicker, more economical control of contagious foot rot.

Each pack contains: 2 fl. ozs. Chloromycetin 10%
2 fl. ozs. propellant.

Chloromycetin Tincture 10% for brush application is still available.

Supplied in bottles of 2 and 16 fl. ozs. with brush.

WPS-1058

PARKE-DAVIS

*TRADE MARK

PARKE, DAVIS & COMPANY
Inc. U.S.A. Liability Limited.
HOUNSLOW, MIDDX. TEL : HOUNSLOW 2361

REFERENCES

BOYDEN, S. V. (1951) : *J. exp. Med.*, **93**, 107.

CHANDLER, A. C. (1953) : *J. Egypt. med. Ass.*, **36**, 811.

COOMBS, R, R. A. & FISET, M. L. (1954) : *Brit. J. exp. Path.*, **35**, 472.

KAGAN, L. G. (1958) : *J. Immunol.*, **80**, 396.

KAGAN, I. G. & BARGAI, U. (1956) : *Amer. J. trop. Med. Hyg.*, **5**, 380.

MAYER, M. M., OSLER, M., & HEIDELBERGER, M. (1946) : *J. exp. Med.*, **84**, 535.

ROGERS, W. P. & SOMMERVILLE, R. I. (1957) : *Nature (Lond.)*, **179**, 619.

SOULSBY, E. J. L. (1956) : *J. Helminth.*, **30**, 129.
(1957) : *J. Helminth.*, **30**, 145.
(1958) : *J. comp. Path.*, **68**, 345.
(1960) : *Vet. Rec.*, **72**, 322.

SOULSBY, E. J. L. & COOMBS, R. R. A. (1959) : *Parasitology*, **49**, 505.

SOULSBY, E. J. L., SOMMERVILLE, R. I., & STEWART, D. F. (1959) : *Nature (Lond.)*, **183**, 553.

SOULSBY, E. J. L. & STEWART, D. F. (1960) : *Aust. J. agric. Res.* (In the Press).

STEWART, D. F. (1950a) : *Aust. J. agric. Res.*, **1**, 285.
(1950b) : *Aust. J. agric. Res.*, **1**, 413.
(1950c) : *Aust. J. agric. Res.*, **1**, 427.

THORSON, R. E. (1951) : *J. Parasit.*, **37**, suppl. 18.

II. THE RED CELL-LINKED ANTIGEN TEST

THE red cell-linked antigen test was described by Coombs and Fiset (1954) as a means of detecting complete and incomplete antibodies to egg albumin in human serum. Such a test depends upon the linkage, by chemical means, of an antigen to antibody globulin which has been rendered non-agglutinating by photo-oxidation, this artificial unit then being attached to a red cell indicator by means of the antibody globulin. Antibodies homologous to the linked antigen either cause direct agglutination, or, if they are incomplete antibodies, require the addition of an antiglobulin serum before haemagglutination can be detected.

The use of such a system was considered in the study of immunity to parasites in the hope, first, that it might be able to detect antibodies in low concentration in such tissues as lymph glands and abomasal or intestinal mucus. Previous experience with such tissues, using complement fixation techniques, has shown that the materials possess a marked anti-complementary effect which makes the interpretation of results extremely difficult. It was anticipated that antibody levels might be of a low order and it would be desirable to use antiglobulin techniques to demonstrate any antibody present. Further, it was desirable to use a red cell as an indicator since there are no readily available nematode tissues or organs which can be used as agglutinating agents. While it is possible to absorb *Haemonchus contortus* antigen on to sheep cells after the technique of Middlebrook and Dubos (1948) the titres obtained even with strong antisera are of too low an order to be of any value in detecting anti-

bodies in tissues using direct agglutinating techniques, and even antiglobulin or conglutinating techniques do not enhance the titre greatly. Though the tanned red cell technique can be used to detect anti-nematode antibodies (Soulsby, 1960) it was considered that even though the red cells were coated with antigen they would also adsorb serum or tissue protein and would therefore react with an antiglobulin serum. The red cell-linked antigen system offers the advantages that high titres can be obtained with it and also as far as can be ascertained only antibody directed against the linked antigen will be detected by either direct agglutination or antiglobulin techniques.

The second reason for using such a test system was that it would be able to detect incomplete antibodies. It is well known that hypersensitivity is a feature of helminth infections, one of the outstanding examples of this being the self-cure mechanism in *H. contortus* infection in sheep (Stoll, 1929; Stewart, 1953), and incomplete antibodies are frequently associated with this type of immunological manifestation.

Consequently a series of sera was examined which was selected according to the immune status of the animal. Similarly the mesenteric lymph glands and abomasal or intestinal mucus of various sheep were examined for the presence of incomplete antibodies.

MATERIALS AND METHODS

Antigen. A 5 per cent. *H. contortus* third-stage larval protein antigen was prepared by precipitation with saturated ammonium sulphate. It was found that the heated *H. contortus* antigen as used for complement fixation tests (Stewart, 1950a) caused precipitation in the system when chemical linkage was carried out.

Sheep red cells. These were preserved in Alsever's solution and were washed three times in veronal buffer (Mayer, Osler and Heidelberger, 1946) before use.

Rabbit anti-fowl red blood cell serum. This is an anti-Forssman serum and was prepared by giving rabbits several courses of fowl erythrocytes intravenously. The resulting sera had a direct agglutinating titre for sheep red cells (cross-reaction being due to the Forssman antigen on sheep cells) of between 1 in 320 and 1 in 640 and a sensitizing titre (detectable by the use of sheep anti-rabbit globulin serum) of between 1 in 20,000 and 1 in 40,000. The globulin portion of this serum was obtained by precipitation with ammonium sulphate and after suitable washing and dialysis the protein concentration was adjusted to 2.5 per cent.

The 2.5 per cent. globulin solution of the rabbit anti-fowl erythrocyte serum was then exposed to a strong light source (3,000 lumens) in the presence of the photosensitizer Eosin Y (1 ml. of 1 per cent. aqueous Eosin Y per 10 ml. of globulin). The manipulation was carried out in a 100 ml. flask fitted with a stopper carrying two glass entry tubes each of which was provided with a stop-cock. Inside the flask was placed a test tube containing 10 per cent. potassium hydroxide. The flask was then flushed through with oxygen and

placed in a water bath at 23° C and agitated continuously. (The light source was kindly supplied by the Photometry Department of the Commonwealth Scientific and Industrial Research Organization, Sydney.)

Samples of the globulin were removed at intervals and tested for their direct agglutinating and sensitizing action on sheep red cells. It was found that after a period of approximately 30 hours almost all trace of direct agglutination had disappeared whilst a substantial sensitizing titre (1/640) still

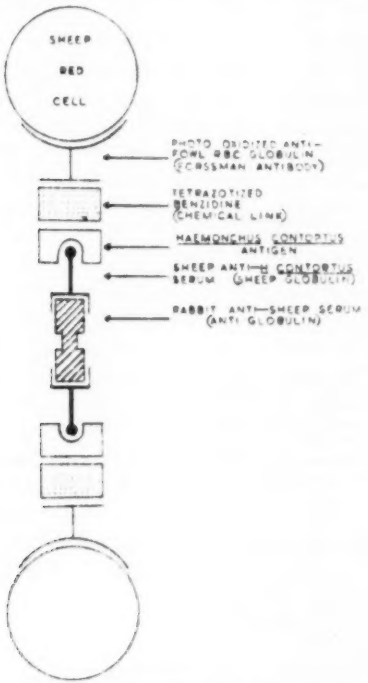


FIG. 1.—Diagrammatic representation of the red cell-linked antigen system used to detect incomplete antibodies in gastro-intestinal nematode infections in sheep.

remained. This photo-oxidized globulin was stored at −20° C until it should be required.

Conjugation of H. contortus *antigen with photo-oxidized globulin.* This generally followed the procedure detailed by Coombs and Fiset (1954). To 1 ml. of 5 per cent. *H. contortus* antigen was added 1 ml. of the photo-oxidized rabbit anti-fowl erythrocyte globulin and 0.16 ml. of tetrazotized benzidine. All reactions were carried out at less than 4° C. An hour after being mixed the solution was neutralized to pH 7.2 with 1 M-sodium bicarbonate and it was then dialysed against saline overnight. The resulting conjugate was stored at −20° C until required.

TABLE I—THE LEVEL OF COMPLETE AND INCOMPLETE ANTIBODIES IN SHEEP SERA USING THE RED CELL-LINKED ANTIGEN TEST

Serum and Date	*State of Infection in Host*	*Incomplete Antibody Titre*	*Direct Agglutination Titre*
112 31–3	Rising egg count	1,280	—
765 29–4	Falling egg count	1,280	—
765 21–4	Rising egg count	1,280	—
765 14–4	Rising egg count	2,560	—
765 8–4	Low egg count	1,280	—
768 21–4	High egg count	80	—
735 21–4	Low egg count	1,280	—
781 21–4	High egg count	160	—
726 21–4	Rising egg count	2,187	81
726 28–4	Falling egg count	2,187	27
726 5–5	Rising egg count	6,000	27
762 12–5	Marked falling egg count	2,187	27
726 19–5	Low egg count	729	81
726 26–5	Rising egg count	2,187	81
726 2–6	Marked falling egg count	2,187	243
726 9–6	Negative egg count	6,561	81
726 16–6	Very low egg count	2,187	81
726 23–6	Negative egg count	2,187	81
726 30–6	Negative egg count	6,000	81
726 7–7	Negative egg count	2,187	81
929 14–4	High egg count	20,000	27
929 21–4	Falling egg count	20,000	27
929 28–4	Rising egg count	20,000	81
929 5–5	Marked rising egg count	60,000	81
929 12–5	Marked falling egg count	60,000	81
929 19–5	Marked falling egg count	60,000	81
929 26–5	High egg count	20,000	81
929 2–6	Marked falling egg count	20,000	81
929 9–6	Very low egg count	60,000	81
929 16–6	Very low egg count	20,000	81
929 23–6	Very low egg count	20,000	81
777 14–4	Very high egg count	2,187	27
777 21–4	Very high egg count	6,561	81
777 28–4	Falling egg count	2,187	81
777 5–5	Moderate egg count	2,187	27
777 12–5	Marked rising egg count	2,187	81
777 19–5	Very high egg count	6,561	81
777 26–5	High egg count	2,187	81
777 2–6	Falling egg count	6,561	81
777 9–6	Falling egg count	6,561	81
777 16–6	Moderate egg count	2,187	27
777 32–6	Rising egg count	2,187	27
781 28–4	Very high rising egg count	60,000	27
781 5–5	Very high falling egg count	60,000	81
781 12–5	Very high falling egg count	20,000	27
781 19–5	Very high rising egg count	20,000	81
781 26–5	Very high falling egg count	20,000	81
781 2–6	Marked falling egg count	20,000	27
781 9–6	Marked falling egg count	60,000	81
781 16–6	Rising egg count	60,000	81
781 23–6	Rising egg count	60,000	81
781 7–7	High egg count	60,000	81
781 14–7	Rising egg count	60,000	27
781 21–7	Very high egg count	20,000	77
F.D.1.	Newborn lamb before suckling	Neg.	Neg.
F.D.2.	Newborn lamb before suckling	Neg.	Neg.

The sheep red cell—*H. contortus* antigen unit was prepared by mixing one part of 5 per cent. washed sheeps cells with one part of the photo-oxidized fowl red cell antibody solution conjugated with the *H. contortus* antigen. After incubation for 30 minutes at 37° C the cells were recovered by centrifugation, washed twice with veronal buffer and suspended to give a 0.25 per cent. suspension.

Sera. Sera were obtained from sheep infected with *H. contortus* or *Trichostrongylus* spp., from worm-free lambs (except *Strongyloides*) and from newly-born lambs.

Before use all sera were absorbed twice with an equal volume of packed sheep red cells (washed six times) to remove unwanted isophile antibody. Since preliminary tests showed that the titres of incomplete antibodies were frequently high, serial dilutions of sera were made either on a geometric progression basis or on a logarithm of three basis, using 0.2 ml. as the unit volume. An equal volume of a 0.25 per cent. suspension of sheep cells linked with *H. contortus* antigen was added to each tube. Following incubation at 37° C for two hours, direct agglutination was recorded using a microscope and a small sample of the deposited cells. The cells were then washed three times in an excess of veronal buffer, and suspended finally in one drop of veronal buffer which was then transferred to small tubes. One drop of a 1 in 5 dilution of rabbit anti-sheep serum was added to each tube and incubation was carried out for a further two hours, after which haemagglutination was recorded. Any haemagglutination which was observed after the use of the rabbit anti-sheep serum was regarded as incomplete antibody.

In order to give a classification of the system which was used, a diagrammatic representation of the technique is given in Fig. 1.

Rabbit anti-sheep serum. This was prepared by injecting sheep serum into rabbits on several occasions. This serum was inactivated at 56° C for 30 minutes and absorbed free of agglutinins with sheep cells which had been washed six times.

RESULTS

It was possible to carry out tests on some 54 sera which were selected from animals showing various degrees of immunity. The results of these tests are presented in Table I.

These results show that there is no general relationship between the incomplete or the complete antibody titre and the state of immunity. In some cases the incomplete antibody titre is very high.

The lymph glands of several sheep were examined for incomplete antibodies. The lymph glands associated with the abomasum or the mesenteric lymph glands were obtained as soon as possible after slaughter and frozen to —20° C. When required, the lymph gland was ground in the frozen state with sterile sand to an emulsion with an equal weight of veronal buffer. The supernatant fluid obtained after centrifugation was regarded as neat lymph extract. The results of these tests are presented in Table II.

As with the results on serum the level of incomplete antibodies in lymph gland emulsions shows no obvious relationship to the degree of resistance.

An attempt was made to demonstrate antibodies in abomasal and intestinal mucus of sheep infected with either *H. contortus* or *Trichostrongylus* spp. using a straightforward saline extract of such mucus. No specific haemagglutination was observed. An attempt was made to extract any antibody present in the mucus by the use of the agar gel technique described by Laing (1956) for obtaining antibodies from vaginal mucus in *Vibrio fetus* studies.

In no case, however, was it possible to demonstrate antibodies in any of the mucus samples despite the fact that in two sheep the titre of incomplete antibodies in the serum was 1 in 2,187 and 1 in 20,000, and 1 in 64 in the lymph glands.

TABLE II—THE LEVEL OF COMPLETE AND INCOMPLETE ANTIBODIES IN LYMPH GLAND EMULSION USING THE RED CELL-LINKED ANTIGEN TEST

Sheep	*State of Infection in Host before Slaughter*	*Incomplete Antibody Titre*	*Direct Agglutination Titre*
155	High egg count	64	—
781	High egg count	64	—
777	High egg count	64	—
153	Low egg count	32	—
183	High egg count	4	—
211	High egg count	—	—
123	High egg count	4	—
159	Negative egg count	4	—
94	Very low egg count	16	—
206	Very low egg count	16	—
786	Very high egg count	500	—
172	Low egg count	32	—

DISCUSSION

The system which has been used in these tests demonstrates that it is possible to detect antibodies, high levels of which were found in some instances, in serum ; it is also possible to use this system to detect antibodies in materials such as lymph gland emulsions which are not amenable to the usual serological tests. It has the advantage that an antiglobulin technique can be used to enhance the reactions.

Where direct agglutination occurred with the system it was considered that agglutinating and therefore potentially precipitating and complete antibodies to the *H. contortus* antigen were present. Where an antiglobulin serum was required to demonstrate sensitization of the red cell antigen unit it was considered that such antibodies came into the category of incomplete antibodies.

Interest was centred upon incomplete antibodies since these are generally accepted to be close to the character of the hay fever type of antibody. It is well known that hypersensitivity is a feature of helminth infections. This is instanced by the numerous infections which produce skin sensitivity which is used as a means of diagnosis. The skin reaction to antigen is generally of the immediate type, thus being distinct from the delayed or tuberculin type of response.

It has been possible, by the criteria presented, to show that incomplete antibodies occur in helminth infections. It has not been possible to equate the level of these antibodies with the level of resistance. Whether in fact one should look for a definite relationship between incomplete antibody titre and egg count is open to question. Whereas the level of complete antibodies, as measured by such tests as complement fixation and haemagglutination, shows an inverse relationship to egg counts (see Stewart, 1950b ; Soulsby, 1957), the mere presence of incomplete antibodies may be a sufficiently acceptable criterion. It is also open to question whether it should be anticipated that these incomplete antibodies play any part in the mechanism of resistance to infection. It may well be that they serve as skin-sensitizing antibodies but have no role to play in actual protection.

It has been possible to demonstrate antibodies in extracts of lymph glands by the technique described. This is of interest in that it indicates that antibodies can be found near the site of the local immunological reaction, but whether the antibody detected was formed in the lymph gland or in the local tissue drained by the lymph gland is undecided.

The failure to find any evidence of antibody in abomasal or intestinal mucus was disappointing. Since both the parasites in question live essentially in the lumen and the mucosa of the digestive tract it might be anticipated that mucus from this area would in fact be quite rich in antibodies. Despite the fact that at least two sheep had high levels of incomplete antibodies in serum and in lymph glands no antibody could be detected in the mucus samples. It may be that helminth antibodies do not diffuse into mucus and they may be found elsewhere ; this has yet to be determined.

SUMMARY

A red cell-linked antigen system has been used successfully for the detection of incomplete antibodies to gastro-intestinal nematodes infecting sheep. Such antibodies were detected in serum, sometimes at a high level. No obvious relationship between the level of incomplete antibodies and resistance could be detected. Antibodies were detectable in extracts of lymph gland but all tests on mucus samples from the abomasum and small intestine were negative.

ACKNOWLEDGEMENT

It is a pleasure to acknowledge the valuable assistance during this work of Mr. Arthur Rowlatt, whose diligence and industry allowed so much to be done.

REFERENCES

Coombs, R. R. A., & Fiset, M. L. (1954) : *Brit. J. exp. Path.*, **35**, 472.
Laing, J. A. (1956) : *F.A.O. Agric. Stud.*, No. 32.
Mayer, M. M., Osler, M., & Heidelberger, M. (1946) : *J. exp. Med.*, **84**, 535.
Middlebrook, G., & Dubos, R. (1948) : *J. exp. Med.*, **88**, 521.
Soulsby, E. J. L. (1957) : *J. Helminth.*, **31**, 145.
(1960) : *Brit. vet. J.*, (In the Press).
Stewart, D. F. (1950a) : *Aust. J. agric. Res.*, **1**, 285.
(1950b) : *Ibid.*, **1**, 427.
(1953) : *Ibid.*, **4**, 100.
Stoll, N. R. (1929) : *Amer. J. Hyg.*, **10**, 384.

(*Received for publication 4 July, 1960*)

AN ANALYSIS OF CATTLE POPULATION TRENDS AND CATTLE OWNERSHIP IN SELECTED AREAS OF NYASALAND

By K. W. Aspinall

Zomba, Nyasaland

Nyasaland is a long narrow country with the long axis running north-south. It stretches from 9° to nearly 18° south, a distance of some 520 miles, and from 32°45′ to nearly 36° east, a width of 120 miles at the widest point narrowing to hardly 40 miles at the narrowest point. It is bounded to the east by Lake Nyasa for some 340 miles and by Portuguese Mozambique, to the north by Tanganyika Territory, to the west by Northern Rhodesia and Portuguese Mozambique, which latter country also bounds it to the south (Fig. 1).

There are some 36,786 square miles of land area which is divided for administrative purposes into three Provinces called the Northern, of 10,664 square miles, the Central, of 14,007 square miles, and the Southern, of 12,115 square miles. No census of the human population has been taken since 1948 but it is estimated to number in the region of 2,750,000 and to be increasing at the rate of perhaps 5 per cent. per year. The human population is divided between the three Provinces in the following proportion, Northern 16 per cent., Central 36 per cent., and Southern 48 per cent. The economy of the country is based on agriculture, the largest single export crop in value being tea and the second largest tobacco, the former grown entirely in the Southern Province and the latter mainly in the Central Province with considerable acreages in the Southern Province.

It will be seen therefore that the pressure of human population and the acreage of cash crops severely limits the area available for cattle and other livestock. This pressure is most evident in the south and declines the further north in the country one goes. The total cattle population numbered 356,514 head at the 1959 census, of which 341,734 are owned by Africans, and of which 29,237 are found in the Southern Province, 188,285 in the Central Province, and 124,21 in the Northern Province. It is with African cattle ownership that this paper is concerned.

The majority of land in Nyasaland is held in communal ownership in the African Trust Land areas; the small amount held by individuals either under freehold or leasehold tenure is largely in the hands of non-Africans, the number of Africans actually holding their own land being negligible. It follows

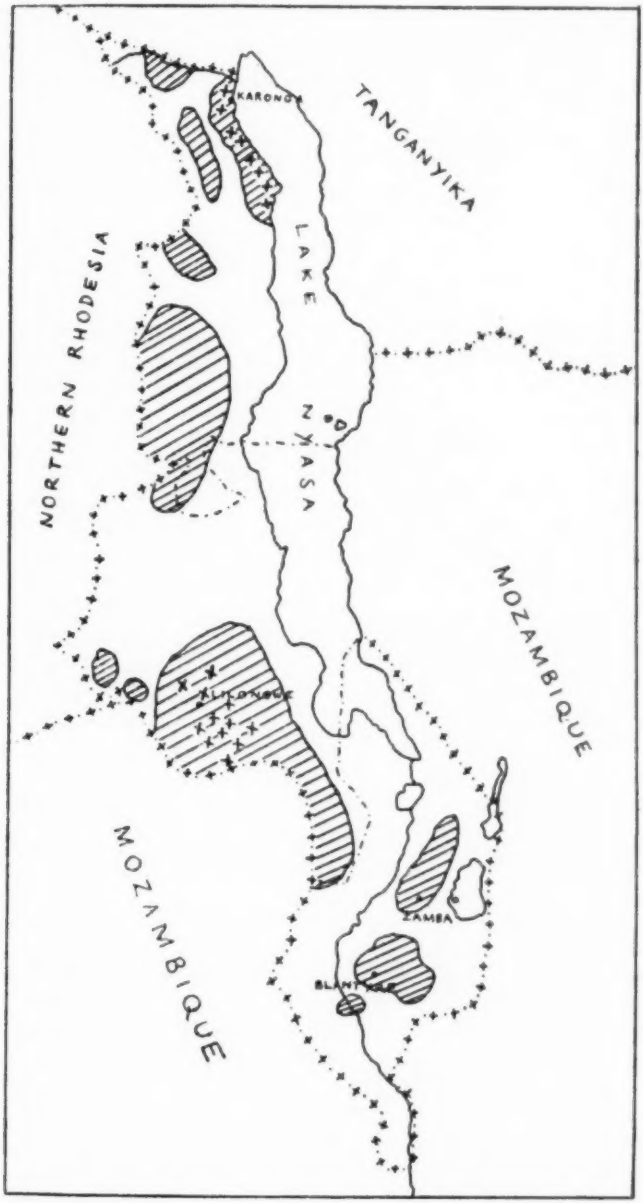


FIG. 1.—Outline map of Nyasaland showing dipping areas (shaded) and sites of dipping tanks where data were obtained.

therefore that the improvement of land for better production is difficult to achieve, as improvements desired by an individual are often contested by his more conservative or merely more lazy neighbours. Cattle are held by family groups, the actual ownership for the purposes of description and registration at dipping tanks being vested in an individual who may or may not be the head of the family. Little information is available on the actual ownership of cattle or rather on the various divisions within the family in which ownership is vested. Suffice it to say that when an animal is disposed of the decision is frequently made at a full scale family conference.

It will be apparent that, with the great preponderance of the human population in proportion to cattle, there is a constant demand for animal products—for milk in the vicinity of the main townships, and for beef from all areas, and more particularly from those where it is possible to move cattle to the consuming areas in the south where the principal townships are to be found. In the absence of incentive to improve individual holdings owing to the communal use of land the only way that productivity can be increased is by increasing the numbers of cattle. Since, in the main, animal products have a unit acreage return considerably less than that which may be expected from a cash crop, such as tobacco, the tendency is for crops to encroach on pastures, and, even where this is not the case, for crops to be planted close to water and thus to restrict cattle movement to the watering points. It is difficult for such a community to assess its agricultural needs in an objective fashion and the quicker return is often favoured to the detriment of the land.

The stock population of the Central Province is the most favourably placed to benefit from high-level sales to the Southern Province towns, and to obtain sufficient grazing to make a reasonable density of cattle population possible. In the Northern Province the distance from markets and the prevalence of tuberculosis makes stock trading unpopular since an animal may be taken south with great effort only to be condemned on reaching the factory. Nevertheless the Northern Province and particularly the most northern District, Karonga, is far more dependent economically on animal products such as hides and ghee. As will be seen there is a large internal demand for slaughter stock.

The level of stock management is primitive in the extreme, the most simple management techniques being rarely carried out. Thus the cattle are kept in their pole yards or *kholas* until very late in the morning, and are returned to them early in the evening, so that grazing is confined to a small period in the hottest time of the day. The *kholas* are often hard and exposed in the dry season, when the nights are frequently cold, and wet and muddy in the wet season when cattle often cannot lie down for fear of being suffocated in mud. It is probably true to say that an unusually wet season causes greater mortality among African-owned stock than an unusually dry one. In addition to the management hazards the cattle have to contend with a variety of tick-borne diseases, notably East Coast fever (*Theileriasis*), heartwater (*Rickettsiosis*) and redwater (*Prioplasmosis*). In the vicinity of fly belts trypanosomiasis constitutes an additional and highly lethal hazard.

MATERIAL AND METHODS

For many years the Nyasaland Veterinary Department has pursued a policy of installing dipping tanks in the cattle-holding areas with the object of providing control of the tick-borne diseases and a centre where better management techniques, including the provision of better housing, can be demonstrated. Sales of livestock products are also arranged from these centres. In order to make disease control effective all cattle within a five-mile radius must be presented to the tank each week for dipping, the name of the owner, or family headman, being entered in a register against which the cattle attendances are recorded. Provision is made in the register to record births, entries due to movement (on permit) from outside the dipping tank area, exits due to movement outside the area (also on permit), slaughterings, deaths due to disease, deaths due to predatory animals, and animals lost in between dippings (provision being made for animals found to return to the count). A charge of one shilling per head per year is made for dipping, exemptions being made from payment, although not from dipping, of animals under the age of eighteen months. The dipping assessments and payments are made once a year at each tank when the register is re-entered and corrected in detail by the officer in veterinary charge of the district where the tank is found. In all there are 117 dips and a number of spraying stations each of which is given a departmental reference number in accordance with its location. These numbers are used in the text.

The first dip was built in 1916, and the first composite dipping scheme was launched in the early 1920's, dips having been acquired from private owners or built on an *ad hoc* basis prior to that date. At the present time 230,060 cattle are dipped, roughly 67 per cent. of the total number of 341,734 African-owned cattle. It should be mentioned that this average figure is not applicable to every province. The breakdown is as follows : Northern Province 55,300 dipped out of 124,212 (44 per cent.), Central Province 157,356 out of 188,285 (86 per cent.), Southern Province 17,404 out of 29,237 (59 per cent.).

It follows that the information recorded in the dipping register and checked at the annual assessment provides as accurate a record of transactions and fluctuations in the cattle population as may be expected in a primitive community. The data compiled over three years at twelve dipping tanks at Lilongwe in the Central Province have been closely examined. These tanks are all situated in the centre of the densest cattle population in the country, in an area which has received a considerable amount of attention in regard to tick-borne disease prevention and the improvement of animal management methods. The cattle population has increased overall in the area of the twelve tanks by 9.4 per cent. in the period under review. The object of the analysis was to obtain the following information :

1. The pattern that this increase has taken in the area of each individual tank.
2. The pattern of births and their fluctuation throughout the year together with the birth-rate.
3. The relative mortality.

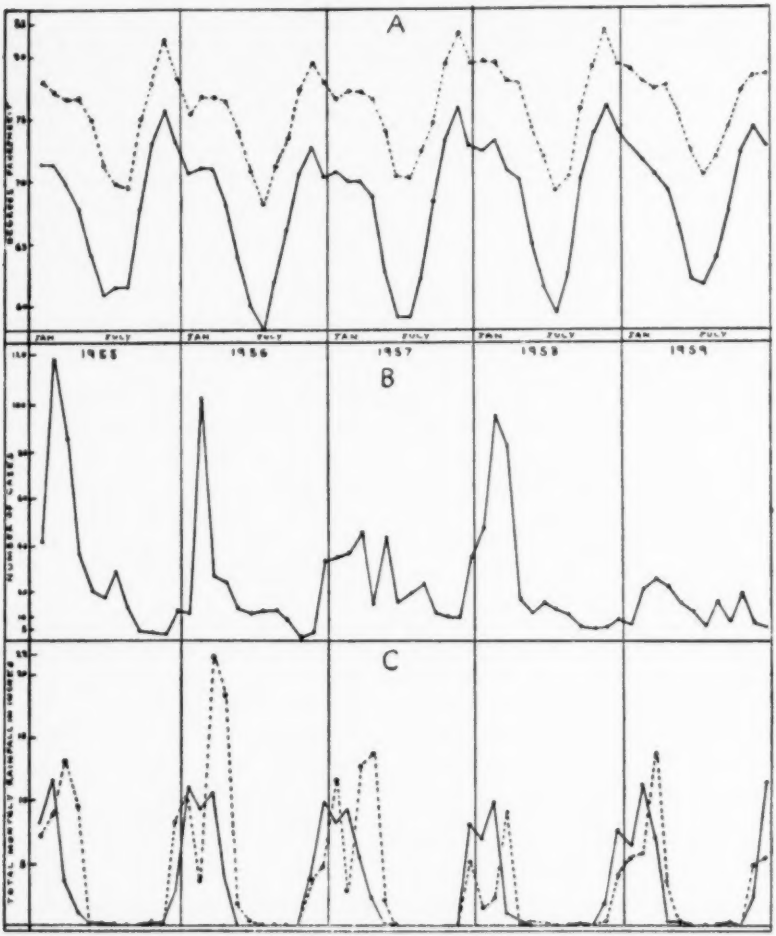


FIG. 2. — A comparison of monthly temperature and rainfall from 1955 to 1959 in in Lilongwe and Karonga, Nyasaland, with numbers of microscopically confirmed cases of East Coast fever. A. Temperature in degrees Fahrenheit at Lilongwe shown ———, at Kar onga shown ----------. B. Microscopically confirmed cases of East Coast fev erin Nyasaland (diagnosis affected by the Emergency in that year). C. Rainfall in inches at Lilongwe shown ———, at Karonga shown ----------.

4. The relative productivity as judged by the number of cattle slaughtered.
5. By a st udy of the numbers of cattle recorded as belonging to individual owners to deduce whether the increase was due to an increase in the overall number of families keeping cattle, or an increase in actual numbers kept by families already recorded.

TABLE I—CATTLE POPULATION AT DIPPING TANKS IN THE LILONGWE DISTRICT FROM 1ST SEPTEMBER, 1956, TO 31ST AUGUST, 1959

Dipping Tank	*Number of Cattle on 1/9/56*	*Difference in numbers between animals permitted "in" and "out"*	*Number of Births*	*Cattle Losses*					*Number of Cattle on 31/8/59*	*Difference between 1/9/56 and 31/8/59 — Decrease — Increase +*	*Calculated number of Cows*	*Calving Rate per annum*
				By Disease	*By Predators*	*By Slaughter*	*Missing Animals*	*Total Loss*				
Namaguya C.P.L. 1	3,292	682 (7·1%*)	2,125 (21·5%*)	113 (1·2%*)	247 (2·5%*)	672 (7·1%*)	172 (1·7%*)	1,886 (19·6%*)	3,469	+177 (5·4%)	1,909 58%	39%
Malimbwe C.P.L. 2	3,368	846 (8·3%*)	2,651 (26·2%*)	112 (1·0%*)	710 (7·0%*)	856 (8·4%*)	191 (1·9%*)	2,715 (26·6%*)	3,221	−147 (4·3%)	1,953 58%	43%
Masula C.P.L. 3	3,637	157 (1·4%*)	2,390 (21·8%*)	215 (2·1%*)	258 (1·7%*)	770 (7·1%*)	191 (1·7%*)	1,591 (14·0%*)	3,466	−171 (4·7%)	2,109 58%	39%
Kalumbu C.P.L. 4	3,480	544 (5·1%*)	3,203 (30·6%*)	34 (3·0%*)	699 (6·6%*)	1,199 (11·4%*)	14 (0·1%*)	2,490 (23·5%*)	4,140	+660 (18·9%)	1,931 58%	57%
Nathenje C.P.L. 5	3,583	281 (2·5%*)	2,598 (24·5%*)	66 (0·6%*)	660 (6·2%*)	856 (7·3%*)	225 (2·0%*)	2,098 (18·6%*)	3,987	+404 (11·2%)	2,077 58%	41%
Nanjiri C.P.L. 6	3,849	969 (8·3%*)	2,751 (23·8%*)	71 (0·6%*)	213 (1·9%*)	1,073 (8·8%*)	12 (0·1%*)	2,338 (19·7%*)	4,121	+272 (7%)	2,232 58%	41%
Mkhoma C.P.L. 7	3,399	656 (6·4%*)	2,640 (25·0%*)	40 (0·3%*)	216 (1·1%*)	852 (8·4%*)	180 (1·8%*)	1,944 (18·0%*)	4,011	+612 (18%)	1,971 58%	44%
Likuni C.P.L. 8	4,159	115 (0·7%*)	2,533 (20·2%*)	259 (2·2%*)	539 (4·4%*)	911 (7·4%*)	446 (2·7%*)	2,270 (17·4%*)	4,336	+177 (4·2%)	2,412 58%	33%
Lingadzi C.P.L. 9	3,785	491 (4·3%*)	3,113 (27·2%*)	180 (1·6%*)	323 (2·9%*)	1,370 (12·5%*)	31 (0·2%*)	2,395 (21·5%*)	4,450	+665 (17·5%)	2,193 58%	47%
Mbabzi C.P.L. 10	5,958	773 (3·1%*)	4,980 (27·8%*)	105 (0·4%*)	709 (3·9%*)	1,981 (11·0%*)	274 (1·5%*)	3,842 (19·9%*)	6,641	+683 (11·4%)	3,455 58 %	48%
Chimbalanga C.P.L. 11	1,167	281 (7·9%*)	660 (18·8%*)	20 (0·5%*)	232 (6·7%*)	228 (6·4%*)	1 (0·4%*)	775 (21·9%*)	1,037	−130 (11·1%)	677 58%	32%
Jumpha C.P.L. 12	4,871	816 (5·5%*)	3,522 (23·7%*)	146 (1·0%*)	544 (3·7%*)	1,584 (10·4%*)	20 (0·1%*)	3,110 (21·1%*)	5,231	+360 (7·3%)	2,825 58%	41%

* Percentages per annum

To form a contrast, comparable data were also analysed in general terms at nine dipping tanks in the Karonga District where the conditions differ widely from those in Lilongwe.

In addition the trends in cattle ownership were examined at all dipping tanks over five years and the comparisons drawn make it possible to predict in part the lines of future development and to emphasise the veterinary problems which must be solved in order to place the African livestock industry on a sound basis and to integrate cattle into an improved farming routine.

RESULTS

(A) LILONGWE DISTRICT

Lilongwe is situated on a plain between 3,000 and 3,500 feet above sea level and the areas studied are within relatively easy distance of the township (Fig. 1). The majority of the rainfall occurs between December and March and there is a relatively long dry, cool winter period between the end of April and the beginning of November (Fig. 2).

Fluctuations at Individual Tanks

The combined statistics are given in Table I. It will be noted that the pattern is not even at all tanks, some showing a considerable increase over the period and others a decrease. In this connection the decrease recorded at Masula tank C.P.L.3 should be disregarded as there was an unexplained movement of a number of herds out of the area which was not recorded in the register. In general the percentage of cattle lost to the tank area is relatively constant for each dipping tank area, the average for all twelve being roughly 20 per cent. with five tanks showing a figure slightly higher than this and four lower.

The number of births in relation to the total number of stock is rather more variable and fluctuates from 19 per cent. to 31 per cent. It would therefore seem that it is the number of births which regulates population increases and decreases since there appears to be little attempt to cut down sales of stock when the number of births or calfhood survivals are low.

Births and Calving Rates

The percentage births for all twelve dipping tanks in each month of the year expressed as a percentage of all births during that year are given in Fig. 3. While there is some individual variation at the tanks, by far the greater number of births occur between July and November in each year with a peak in August. If this is related back, it will be seen that the majority of successful services occur in November, December, January and February. It will be noted in Fig. 2 that these are the months when rainfall and temperatures are high and when by inference the nutrient levels of the grazing are at their optimum.

Fifty-eight per cent. of cattle in Lilongwe District are cows and heifers and the calving rate is expressed as a percentage of the number of cows calculated at each tank from this figure. It will be noted that it fluctuates from as low as 32 per cent. to as high as 57 per cent. and there is little doubt that this

figure is related to the quantity and quality of grazing available to the cattle (Table I). Thus at Chimbalanga C.P.L. 11 the cattle are herded in hilly country and have little or no access to the swampy areas, known as *dambos*, which preponderate in the region of Kalumbu C.P.L. 4, and which provide a source of dry season grazing.

Relative Mortality

The mortality is recorded under two headings, deaths due to disease and deaths due to predators. Since every recorded death from disease has to be supported by a gland or spleen smear, there is a tendency to put down any

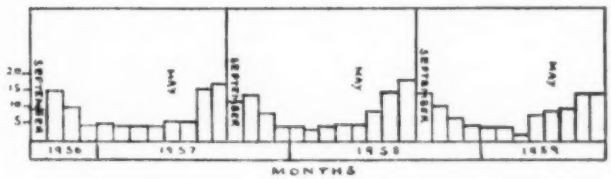


FIG. 3. — Births per cent. by months in the Lilongwe District from September 1956 to August 1959.

death which cannot be supported by the necessary smears to death by predatory animals. While the latter is indeed one cause of mortality it cannot be regarded as of the importance placed upon it by owners, and it is probably wise to regard deaths from both those causes as deaths from disease (Table I). The lowest annual mortality is recorded from Mkhoma C.P.L. 7 and the highest from Malimbwe C.P.L. 2 and Chimbalanga C.P.L. 11. The average overall mortality is 5 per cent., with five tanks showing higher figures and four lower. This represents an avoidable loss each year of 2,400 animals.

In Fig. 2 the actual deaths from East Coast fever throughout the country over a period of five years are plotted against rainfall and temperature. It will be noted that the highest incidence of East Coast fever, and, one can assume also, the other tick-borne diseases, takes place in January and February when the greater number of calves are four to five months of age and are starting to accompany their dams to the grazing.

Calves therefore face a very considerable disease hazard derived from the prevalence of ticks and the diseases they carry at that time in the year. The tendency to restrict grazing in the wetter months (late November to beginning of May) to the vicinity of the village also results in a build-up of internal parasites.

The total losses due to a combination of disease and predators by the month in which they occurred is shown in Fig. 4. It will be seen that mortality closely follows that from recorded cases of East Coast fever (Fig. 2). It is therefore reasonable to suppose that tick-borne diseases are the greatest cause of loss throughout the year and, as stated above, it is probable that deaths said to be due to predators are in fact largely due to this cause.

Relative Productivity

This is shown in Table I. The main reason for importing cattle is to make up a bride price. It can therefore be assumed that imports and exports for this purpose will roughly cancel each other out so that any amounts in excess of the difference between import and export figures represents true exports in the form of slaughter stock. It should be mentioned that a number of slaughter

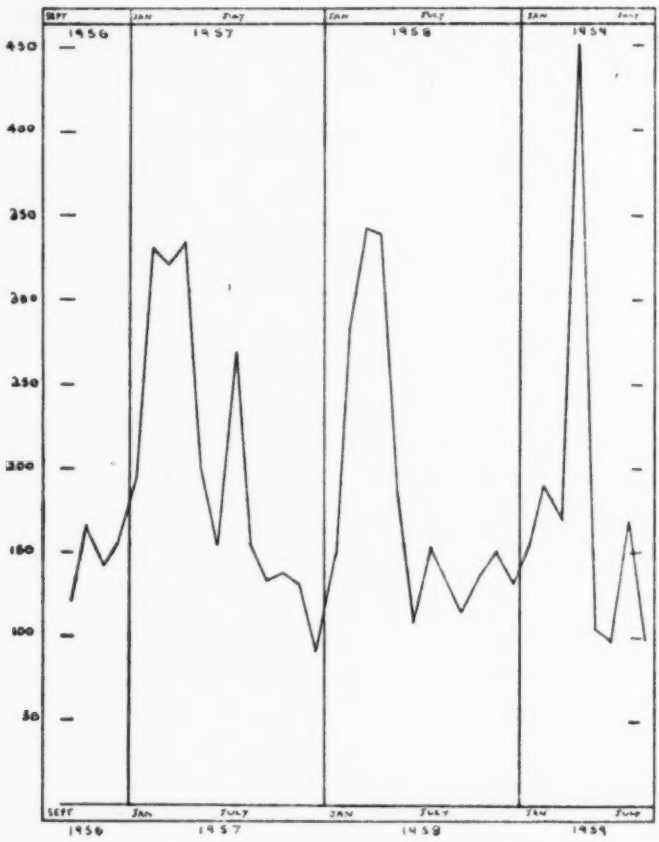


FIG. 4 — Numbers of animals lost from disease and through predators in the Lilongwe District from September 1956 to August 1959.

stock consumed internally are the sick and the lame, destroyed in order to obtain some value for them. However for the purpose of the survey this reason for slaughter has been ignored.

The percentage of the total number of animals sold each year for slaughter varies considerably between tanks, from 8 per cent. in the case of Masula

C.P.L. 3 and Likuni C.P.L. 8, to 17 per cent. in the case of Nanjiri C.P.L. 6, with an overall average of 14 per cent. Nearly twice as many animals are slaughtered for internal requirements as are exported for slaughter elsewhere, the actual average figures per year being 2,204 exported for slaughter, 4,117 slaughtered internally, a total of 6,321 slaughterings in all *per annum*. This represents an annual gross return to the area of £63,210 at an average value of £10 per beast, a conservative estimation which allows for a large margin of profit for the middleman moving animals to townships for sale to butchers.

Cattle Ownership

As has been stated the actual property investment in cattle is difficult to assess on an individual basis; however the names given in the dipping register do not show a great variation from year to year and may be accepted as representing family ownership. All cattle are communally grazed under the charge of children who are supposed to see that they do not stray on to standing crops and that they do not get lost. It should be mentioned that with the increase in primary education herdsmen are becoming more and more difficult to obtain, and it is probable that there is a tendency to herd cattle belonging to several owners together with increasing detriment to the land and the cattle.

In the areas of the twelve tanks under examination there has been a decrease in recorded cattle owners from 2,362 in 1956 to 2,317 in 1959. The average number of cattle held in each family group rose from 17 in 1956 to 18 in 1957, to 19 in 1958, and to 20 in 1959, giving a clear indication that the total increase of 4,627 cattle over the three years has not been due to an increase in the numbers of people owning cattle, but rather to an increase in the number of cattle in the possession of the traditional owners. Over the past 14 years, however, there has been an increase in the numbers of owners from 2,081 to 2,317.

Taking this figure of twenty as a standard holding throughout Lilongwe District, 4,648 family groups must hold a total cattle population of 92,960. Since the human population is assessed at 844,957 people and an average family may be said to number five, there are thus 168,995 family groups in the District. In all probability some twenty people on average have a say in the disposal of each group of cattle. Nevertheless it is apparent that only about 11 per cent. of people in the District have any connexion with cattle, and only 2.9 per cent. are recorded as being directly responsible for them. Yet Lilongwe District holds the densest and the most numerous cattle population of the whole country.

The numbers of cattle actually held by the family groups are of interest. Of the 2,317 cattle owners recorded, 8 own more than 100 cattle, 106 between 50 and 100, 338 between 30 and 49, 1,170 between 10 and 29, and 589 less than 10. It will be seen that rather more than half the people own between 10 and 29 cattle, which under primitive conditions is probably a very convenient number. The most cattle owned by one family group is 173.

TABLE II—CATTLE POPULATION AT NINE DIPPING TANKS IN THE KARONGA DISTRICT FROM 1ST SEPTEMBER, 1956, TO AUGUST 31ST, 1958, WITH SUPPLEMENTARY DATA CONCERNING 1959

Dipping Tank	*Number of Cattle on 1/9/56*	*Difference in numbers between animals permitted "in" and "out"*	*Number of Births*	*Cattle Losses*				*Total Loss*	*Number of Cattle on 31/8/58*	*Difference between 1/9/56 and 31/8/58. Decrease — Increase +*	*Calculated number of Cows*	*Calving Rate per annum*
				By Disease	*By Predators*	*By Slaughter*	*Missing Animals*					
Kaporo N.P.K. 9	2,102	131	772	97	183	570	56	1,037	1,337	−765 (36%)	1,282 (61%)	30%
Ngerenge N.P.K. 10	1,322	211	428	80	45	283	66	685	1,105	−217 (16%)	555 (46%)	38%
Mwawembe N.P.K. 11	1,443	114	562	43	107	361	72	697	1,334	−109 (7%)	981 (68%)	27%
Kayuni N.P.K. 12	1,704	546	1,357	—	94	365	11	470	2,179	+475 (27%)	1,124 (66%)	60%
Mlale N.P.K. 13	2,345	626	1,444	—	137	283	28	1,074	2,548	+203 (8%)	1,430 (61%)	50%
Nyungwe N.P.K. 14	2,116	492	1,168	7	59	226	25	809	2,526	+410 (19%)	1,397 (66%)	41%
Chonanga N.P.K. 15	1,198	149	636	6	56	206	43	460	1,498	+300 (25%)	839 (70%)	37%
Mwaungulu N.P.K. 16	482	64	278	—	2	50	3	119	678	+196 (40%)	159 (33%)	87%
Kwawa N.P.K. 17	402	101	291	3	28	146	27	204	586	+184 (45%)	273 (68%)	50%
All	13,114	2,434 (8% p.a.)	6,939 (27% p.a.)	236 (1% p.a.)	711 (3% p.a.)	2,490 (9% p.a.)	331 (2% p.a.)	5,555 (23% p.a.)	13,791 (3% p.a.)		61%	44%
Sept., 1959	12,556	558 less	1·5–4%									

(B) KARONGA DISTRICT

There are eighteen dipping tanks in the Karonga District of the Northern Province, eight situated in the hilly inland isolated areas and the remainder along the shores of Lake Nyasa. An analysis has been made of the dipping returns from the lake-shore area between September, 1956 and August, 1958 inclusive, from the areas of nine tanks, one additional tank being brought into use only in 1960 (Table II). Records were incomplete in 1959 owing to the necessity to withdraw veterinary services owing to the civil disturbances in the early part of that year. The actual figures of stock numbers in September, 1959, are, however, given and the result of the withdrawal of services will be immediately apparent.

Karonga lake-shore is situated between 1,500 and 2,000 feet above sea level and forms an alluvial plain backed by mountainous areas to the west. It is hot, as shown by the temperature charts in Fig. 2, and tends to be humid because of the close proximity of the lake. Rainfall is higher and more evenly spread throughout the year than is the case in Lilongwe. There is, of course, no lack of water for cattle although at certain times of the year they have to travel quite long distances to get it. The people are rather more interested in their cattle than is the case round Lilongwe but their only sale for slaughter stock is internally, or spasmodically in Tanganyika Territory to the north.

Stock Numbers

Although up to September, 1958, the stock numbers showed an overall increase in relation to 1956 of 3 per cent., by September, 1959, there had been an overall drop of 7 per cent. in comparison with the 1958 figure, so that in fact there were 558 fewer cattle at that time than had been recorded in September, 1956 (Table II), but this position was not constant at all dipping tanks. The dipping tanks are numbered from the north to the south (with the exception of the latest tank N.P.K. 18, which is in Karonga). Thus Kaporo, N.P.K. 9 is the farthest north, being situated close to the Tanganyika border, while Kwawa, N.P.K. 17, is in the south of the District in Florence Bay. In an area close to Kaporo there is a small tsetse fly belt (*Glossina brevipalpis*) which has exerted a considerable influence on the cattle population, and trypanosomiasis is very prevalent in its vicinity while the disease has also spread to some extent by mechanical transmission. The disease has been kept in check in the past by the use of trypanocidal drugs, largely of the phenanthridial group.

It will be seen (Table II) that it is in the three dipping tank areas where the problem of trypanosomiasis is greatest, namely those of Kaporo, N.P.K. 9, Ngerenge, N.P.K. 10, and Mwawembe, N.P.K. 11, that stock decreases are the most apparent. The records for 1959 are not shown but these revealed that a further two tanks showed overall losses, namely those of Kayuni, N.P.K. 12, and Mlale, N.P.K. 13. It is very evident that the withdrawal of services between the end of February and July in that year resulted in a spread of the trypanosomiasis south, not only with an increase in mortality, but also with a

lower calving rate. There is little doubt that very determined and expensive action will now be required to restore the position.

Births and Calving Rates

It will be noted from Table II that birth rates in general follow the same pattern as cattle increases and decreases, and tend to be lowest in the north near the tsetse belt and highest in the south. It will be noted (Fig. 5) that there is no even pattern of births at one time of the year as seen in the figures for the Lilongwe tanks (Fig. 2) and in fact there was a considerable calf crop in June, 1958. This may well reflect the higher level of nutrition on the

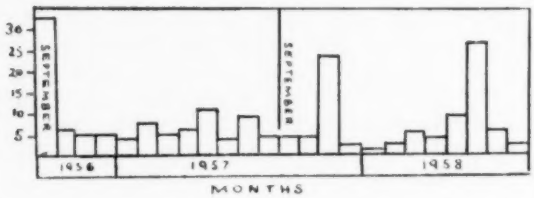


FIG. 5. — Births per cent. by months in the Karonga district from September 1956 to August 1958.

lakeshore and the more even distribution of rain and the higher temperatures. It had been expected that the high temperatures in November would result in a lower conception rate in that month but this does not seem to have been the case. The position is however complicated by the disease factor. Birth-rates are in general better than those recorded at the Lilongwe tanks.

Relative Mortality

This is appreciably less than that recorded for Lilongwe and the difference is difficult to explain, for although the figures for cattle "missing" are considerably greater and some of these may have been diseased, the whole difference cannot be explained on this basis. It is possible that a large number of these animals which were recorded as being "slaughtered internally" were in poor condition as the result of chronic trypanosomiasis but were not included in the diseased group. Mortality figures for early 1959 are not available as no attendances were made at dipping tanks.

Cattle are slaughtered internally in the area at about the same relative rate as in Lilongwe but exports are markedly higher, the sales being largely to the Rungwe District of Tanganyika.

Cattle Ownership

At the 1959 dip assessment there were 1,119 cattle owners in the area owning 12,208 cattle, an average of 11 cattle per family. The number of owners has declined from 1,292 in 1956 and the cattle population declined in comparison with 1958 by 2,195 head. The dipping assessment is normally

carried out in March and April, but in 1959 it was delayed until May and June by the Emergency and this in part affects the comparison of actual cattle numbers. However, it is established that a very considerable number of cattle died because of the inability of the Department to carry out its services. The interruption was due to the destruction by rioters of the dip tanks and their facilities, including the only available bulk stock of trypanocidal drugs.

There are 100,000 people in Karonga District, that is roughly 20,000 families. 51,538 cattle are held, of which 23,826 are dipped. Since the average holding is roughly ten per family, it follows that some 25 per cent. of families are directly concerned in cattle ownership, and on the assumption that some twenty people have some interest, even a nebulous one, in each family-owned group of cattle, it would seem that the whole population of the District has some connexion with cattle.

THE OVERALL PATTERN OF CATTLE OWNERSHIP

An examination has been made in as many areas of the Protectorate as possible to endeavour to determine the trends in cattle ownership. As explained, the dip assessments form the best and perhaps the only reliable basis on which to form an opinion. No other records kept can be regarded as having the same authority, and since payment for dipping is made by the individuals recorded in the registers as owning any given herd of cattle, it is evident that there is a strong incentive to declare ownership in order to spread the financial burden.

While such a survey does not take into account the cattle ownership trends in areas of new occupation, such as those formed by a receding fly belt, it is probable that left to themselves people entering such areas and bringing stock will be those used by tradition to keeping them. Completely new owners must be very few in number.

It is difficult to generalize from the figures available but there is little doubt that increases in cattle population occur coincidentally with an increase in cattle owners. Thus there has been an increase of cattle owners from 2,081 in 1945 to 2,317 in 1959 at the twelve tanks examined in the Lilongwe area. In the same period cattle numbers increased from 37,362 to 46,545, and while the increase has not been smoothly accomplished, nevertheless it has occurred.

Further it should be noted that the increase in cattle owners over the 14-year period has not kept up with the increase in cattle, the average number held per family group having increased from 17 in 1945 to 20 in 1959. Put another way, while the cattle population increased by 24 per cent. the number of owners only increased by 11 per cent., or 236 in fourteen years, a relatively small increase.

Two factors are therefore very noticeable. First, as the density of the human population increases the relative number of people holding cattle decreases. Thus in the Zomba District there has been a decrease in the number of stock owners coincidentally with an increase in stock numbers and an increase in the average holding per family. Second, as this process

proceeds cattle holdings tend to become concentrated in the hands of the chiefs, village headmen and other people of substance, no doubt because such people possess the authority to resist complaints of trespass as arable plots increase in number in accordance with the needs of subsistence agriculture.

DISCUSSION

It is evident that the most important factor limiting livestock numbers, and therefore productivity, is the low level of fertility. This factor is probably due in the main to low nutritive levels except in exceptional cases such as that examined in Karonga where a disease factor further reduces the already low level. Surveys have established the presence of *Brucella abortus* infection in certain parts of the Central Province but it is doubtful whether it is a significant contributory factor to the low birth-rate.

It is a moot point whether any practical advance can be made in individual animal productivity in communally held stock. To get the best out of stock one needs a constant and personal supervision with facilities to open and close grazing in accordance with the agricultural needs of the land and an incentive to conserve winter foodstocks. It will be recalled that herd improvement only started in England once the Enclosure Acts had become established, and the weakness of the common-land system of grazing is a historically proven fact. In short the only long-term solution is individual land holdings, and a series of enclosures.

In the short-term, however, it is evident that an increase of productivity requires an increase in stock numbers with a concurrent increase in the numbers of people holding cattle, and, with the very readily available market, it should be possible to encourage high take-off with little danger of overgrazing except in very localized areas. The increase in numbers is dependent upon a high level of veterinary services to reduce the very high avoidable mortality level, and the adverse results of the complete withdrawal of these services in the face of a direct disease threat is demonstrated in the Karonga District. Further it is evident that an increase of cattle population might be effectively accomplished in the more isolated areas by a positive plan to assist new owners while ensuring that such expansion is fully covered by disease control and prevention services.

SUMMARY

A detailed survey of data collected at twelve dipping tanks in one area and nine in another area of Nyasaland has been examined to obtain an indication of trends and fluctuations in cattle population ownership and the reasons for such fluctuations. The emphasis and effect of veterinary services in a primitively organized agricultural community is also demonstrated.

ACKNOWLEDGEMENT

I am indebted to the Director of Veterinary Services, Nyasaland, for permission to publish this article.

(Received for publication 21 June 1960)

THE SHARE JONES MEMORIAL LECTURE*

By H. V. Hughes

Department of Veterinary Anatomy, University of Liverpool

I. JOHN SHARE JONES

The son of Thomas and Mary Ann Jones, John Thomas Jones was born on August 25th, 1873, at Cefn Mawr, Denbighshire. Thomas Jones, a man of huge physique, was one of the best known agriculturalists in Denbighshire, his success being largely attributable to the fact that he had supplied thousands of pit ponies to collieries in North Wales and Lancashire. His wife, whose maiden name was Share, was a very devout lady ; among her six children, John was the only son. The ties of affection binding together mother and son were unusually great, and there is little doubt but that John Share Jones assumed the name Share, in later years, as a token of his love for his mother.

The young John attended the elementary school at Cefn, and after serving there as a pupil teacher was awarded a scholarship to King's College, London, where he obtained his teacher's certificate about 1893. For some years he taught at Levenshulme, Manchester, but in 1896, on the advice of a pupil-teacher friend, Mary Selina Jones, the lady who was later to become his wife, he decided to enter the Royal Veterinary College, London. He proved a very able student, and after obtaining the diploma of M.R.C.V.S. in 1900 he held appointments at the College as tutor in surgery and demonstrator in anatomy until 1904, when he left to become lecturer in anatomy at the newly established veterinary school of Liverpool University.

To Rubert Boyce, Professor of Pathology at the University, is due the credit for the foundation of the school at Liverpool. He it was who had earlier secured the endowment of a chair of comparative pathology, and who laboured to prepare the ground for he study of veterinary science in the University. While the majority of veterinary surgeons in the locality supported the project, the Council of the Royal College of Veterinary Surgeons expressed their disapproval of the proposed establishment of a second veterinary college in England and its affiliation to the Royal College. One of the professional journals, too, embarked upon a vigorous campaign of opposition. "We have no faith," one reads in a leading article, "in the advancement which is to accrue to us from Liverpool. That some of the university professors and municipal authorities have stretched out a hand to the veterinarian

* Delivered at the Royal Veterinary College, University of London on 1 Octoher, 1959. Part I abridged.

is true, but one cannot avoid a suspicion that the reason is that they may more easily exploit our field of labour and use us as cat's paws for their own benefit."

There was indeed throughout our profession much opposition to the establishment of a new centre at Liverpool. Yet Share Jones, refusing a safer and more lucrative appointment abroad, decided to join the new school. Who but a man of outstanding courage would have embarked upon so stormy and so difficult a venture? Within two years of his coming to Liverpool, he was appointed secretary of the Board of Veterinary Studies, and from that time on he became more and more responsible for the administration of the school. He had firmly resolved that the veterinary school in the University must succeed and he would devote his entire energies to that end. Indeed I would claim that the story of Share Jones's academic life is very largely the history of the struggle for the establishment of veterinary education in universities.

Realising the extent of the opposition to the Liverpool school, Share Jones resolved to carry war into the enemy's lines. In 1912 he was elected a member of the Council of the Royal College of Veterinary Surgeons and we soon read of him urging the Council to take steps to ensure that the value to the nation of our profession in matters of public health was not overlooked. Two years later he was elected Vice-President, but after the first World War when changes were made in the higher offices he was passed over for the presidency. This was a great disappointment, but he realised that the reasons were entirely political.

In 1914, primarily as a result of Share Jones's efforts, Liverpool University had instituted degrees in veterinary science. This was not entirely an innovation—London and Edinburgh Universities had formulated ordinances governing the award of degrees in veterinary science as long ago as 1904 and 1912 respectively—but the Liverpool B.V.Sc. degree was unique in that the course of study included the clinical subjects of medicine and surgery, which the courses for the London and Edinburgh degrees did not. Moreover, it was a condition of award of the Liverpool degree that before graduation a candidate should hold the licence to practise, viz., the diploma of M.R.C.V.S.

These university degrees had never threatened the authority of the Royal College of Veterinary Surgeons, which was the custodian of the one and only portal of entry into the profession, the passing of the examinations leading to the award of the diploma of membership of the Royal College. But in 1920 an application was made by the Universities of London and Liverpool for the recognition of their degrees in veterinary science as licences to practise, and Share Jones suffered from being associated with an act which, in the view of many members of the profession, was calculated to wreck the Royal College of Veterinary Surgeons. The reports of the R.C.V.S. Council meetings, and indeed the correspondence columns of the national press, during this period, indicate how strong was the feeling within the profession generally against any interference with the powers of the College.

Much of the opposition was due to the fear that recognition of the London and Liverpool degrees would lead to applications for similar recognition

from other universities whose standards might not be as high as those demanded by the Royal College of Veterinary Surgeons. Moreover, the only university providing what might be termed a complete course of training was that of Liverpool, where the school was still in its infancy. No one was more acutely aware of the deficiencies of the Liverpool school than Share Jones himself—in 1920 he was the only full-time member of the veterinary profession on the staff. But he had faith in his own university and he was confident that the nation would soon realise that our profession was capable of playing a much more important role in our national economy than it had done in the past. The petitions of the universities were unsuccessful, but Share Jones continued to advocate the need for a higher standard of veterinary education. Whilst some were insisting that the profession was overcrowded he claimed that our numbers were too small.

He was a bold man who would advocate an increase in the numbers of the profession in the early twenties when the schools were turning out more qualified men than ever before. But Share Jones's view of the value to the nation of an enlightened and numerically strong veterinary profession came to be recognised by those in authority, and, in 1925, largely through his efforts, a government grant was made to Liverpool University for the erection of a new veterinary building. The tide had turned, and one of his chief ambitions in life had been realised, for government recognition of a veterinary school within a university had been secured at last. He was elected President of the Royal College in 1928 and in the same year the College honoured him further by awarding him the Steele Memorial Medal.

From his early youth Share Jones had always maintained a keen interest in the animal industry. As early as 1914 he had advocated the establishment of a faculty of animal husbandry and veterinary science in the University of Wales, and in 1929 he stood as a Liberal candidate at the general election, the chief plank in his platform being a plea for better support for British agriculture. This appreciation of the wider conception of our science was intensified by his many visits abroad, and it is significant that in 1934 the University of Berne, recognising his work in this sphere, conferred upon him an honorary doctorate.

The thirties were lean years for the veterinary profession. There was some little unemployment amongst the younger men who had passed through the schools immediately after the first World War, and our oldest and largest college at Camden Town was rapidly falling into disrepair. Towards the end of 1936, however, a committee under the chairmanship of Sir Thomas Maloney, and later Sir Thomas Loveday, was appointed by the Minister of Agriculture to review the facilities available for veterinary education. The committee issued its report shortly before the outbreak of the second World War but in 1944 it was recalled and issued a second report. This recommended not only that veterinary studies should be given full university status but that a degree in veterinary medicine should become a registrable qualification, the Royal College of Veterinary Surgeons being charged with the function of ensuring a sufficient minimum standard of training at all the schools.

Share Jones had retired from his chair of veterinary anatomy at Liverpool in 1938, but he continued to be a member of the Council of the Royal College of Veterinary Surgeons. It might have been expected that the recommendations of the veterinary education committee would have met with his wholehearted approval, but in fact, this was not the case. He could not fail to be gratified with the committee's adoption of the principle of veterinary education becoming absorbed into the universities, but he believed that the one-portal system of entry into our profession would be placed in jeopardy if the degrees in veterinary science awarded by universities were in themselves registrable qualifications to practise the art and science of our profession. In his address as a candidate for election to the Council of the Royal College of Veterinary Surgeons in 1947, when there was considerable controversy amongst members of the profession with regard to the committee's recommendations, he wrote, "It is my opinion that only such graduates as take the final examination of the Royal College of Veterinary Surgeons should use the title of M.R.C.V.S. for professional purposes in addition to the title of their degree." Had he been alive today he would have conceded that his fears had been proved groundless, for we all know how seriously the Royal College discharges its function of ensuring that "minimum standard" of education demanded by the Veterinary Surgeons' Act of 1948. Throughout his life he had always been proud to boast of veterinary science as a profession and he had striven "to uphold the honour and dignity" of our profession. To his intense anxiety to maintain the authority which this College exercises over our profession, binding us into a body corporate, must be attributed the fact that Share Jones whilst still a fervent upholder of the principle of university education clung to his belief that the mark of a veterinary surgeon must be that which is granted by this Royal College.

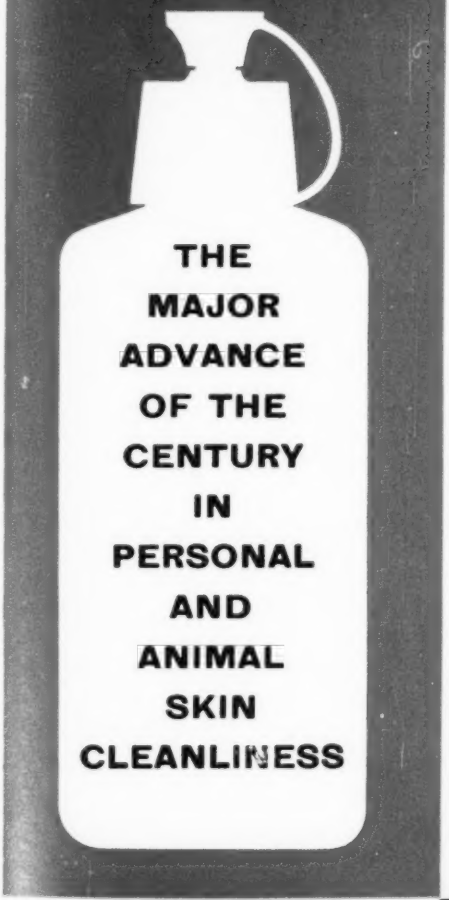
John Share Jones perceived the vision splendid of the mission of our profession. His strivings on our behalf must not be forgotten when that vision will have faded into the light of common day.

II. THE SKIN OF THE DOG

The skin covers the whole of the body, being continuous at the so-called muco-cutaneous junctions with the mucous linings of the mouth, nose, anus, vulva and penis. In this group of membranes one should not overlook the eyelids and conjunctiva which have surface layers derived from the ectoderm.

My remarks will be concerned primarily with the structure of the skin, but since structure and function are intimately associated, may I remind you very briefly of some of the functions which are subserved by different organs of the skin? I use the term "organs" advisedly for it must be remembered

pHisoHex



by BAYER

- A 2-minute wash with pHisoHex ensures virtual sterility of the surgeon's hands and operative area for several hours.
- Application to operative area five days before surgery significantly reduces the risk of post-operative infections.
- pHisoHex provides a bland, non-alkaline, non-irritating and hypoallergenic treatment for non-specific and bacterial dermatoses in small animals.
- Profound deodorising action manifest even in large animal obstetrics.

pHisoHex

BAYER

BAYER PRODUCTS LTD.
EDEN STREET,
KINGSTON-UPON-THAMES, SURREY
TELEPHONE: KINGSTON 7733
TELEGRAMS:
BAYAPROD, KINGSTON-UPON-THAMES

ROUTINE HANDWASH FROM THIS DAY ON

INTERNATIONAL SERUM COMPANY LIMITED

hold a comprehensive range of all antisera and vaccines, antibiotics and specialities for veterinary practice.

New preparations recently introduced include :—

Apocrine

(Chorionic gonadotrophin B.P.) Luteinising hormone
5 × 1,500 I.U. dried substance with 5 × 5 ml. diluent
25 × 1,500 I.U. dried substance with 25 × 5 ml. diluent

Apocrine-A in Oil (P.M.S.)

(Serum gonadotrophin) 25 ml. containing 200 I.U. per ml.

Bilevon

(Hexachlorophene) For control of liver fluke.

Coforta

5% injectable organic phosphorous compound for stimulating the metabolism.

★

Emergency service available at all times for supply of urgent requirements

★

The Paddocks, Frith Lane, Mill Hill, London, N.W.7

Telegrams: Interserum, Norphone, London. Telephone: FINchley 5554.

that the integument is, in reality, a complex mass of tissue composed of a number of parts or organs each with its own peculiar structure and functions.

As an outer covering of the body the skin affords protection from the effects of general rough handling and trauma, and in this connection we recognize its importance as a sensory organ capable of appreciating heat, cold, pain and touch. In the feet we find a modification or development of the protective tissues associated with locomotion, and although the claws of the domestic dog can hardly be compared with those of the cat, in which species they assume the role of weapons, we well know that they can be quite effective digging tools.

Again, as a complete envelope to the body, the skin protects against invasion by macroscopic parasites and micro-organisms and it guards against the ill-effects of exposure to certain deleterious rays. Its pigment granules, which are concerned in this last process, are also able to manufacture vitamin D under the influence of ultraviolet light rays.

The microscopic glands which are scattered throughout almost the whole extent of the skin may be regarded as the units of one vast excretory organ, but there are also the mammary glands, concerned with reproduction, and the glands of the para-anal sacs which are considered to be associated with the peculiarly well-developed olfactory sense of the species. The cutaneous glands also play a part—admittedly not as great in dogs as in man—in regulating body temperature, and they prevent maceration of the surface layers of the body, whilst with those surface layers they also assist in preventing excessive dehydration of the body tissues.

The structure of the skin is fairly uniform throughout the greater part of the body except at the muco-cutaneous junctions and also in the digits where the outer, epidermal, layer is modified and takes the form of pads and claws. In these regions the glands of the skin also become altered. Superficial examination of the skin will show that it is highly elastic, but its attachment to underlying tissues depends on the position in the body. For example, it is very loose in the mid-dorsal line of the neck, whilst it is closely bound down on the inner surface of the ear. The thickness also varies with the position in the body—it is thickest where most wear occurs, such as in the region of the mid-dorsal line of the neck, and in old animals at the point of the hock, whilst it is thinnest over the abdomen, in the groin and in the axilla.

THE EPIDERMIS

The outer of the two main layers of the integument—the epidermis—is a squamous epithelium, and four or five secondary layers are recognized. Considering these layers from the outside to the inside we have :—

1. *Stratum Corneum.* Here the cells are dead, horny and scale-like, their walls having shrunk and become keratinized. The nuclei of the cells have degenerated and cannot be identified. Keratin is one of the albuminoid group of proteins or sclero-proteins with a high percentage of sulphur in its composition. They are insoluble in water but soluble in alkali sulphides—hence the use of barium sulphide as a depilatory.

2. *Stratum Lucidum.* This layer receives its name from the fact that it consists of a thin translucent homogeneous membrane whose cells are ill-defined, with degenerating nuclei which are difficult to recognize. It stains only faintly with acid dyes so that in sections if it appears at all it takes the form of a pale wavy stripe. It is composed largely of eleidin which is an intermediate substance in the conversion of the keratohyalin of the deeper layer into keratin.

3. *Stratum Granulosum.* As its name suggests, granules occur in the cells of this layer. The cells, not so flattened as in the preceding layer, may be arranged in three to five layers, and those of the deeper layers show distinct nuclei. The granules are composed of basophilic keratohyalin and, as these increase in size and number in the more superficial cells, the nucleus disintegrates.

4. *Stratum Germinativum.* This is situated deeply to the granular layer and has been named after the founder of microscopic anatomy, Marcello Malpighi. It is a somewhat thick and uneven layer for it conforms to the irregularities of the underlying dermis. A stratum of single columnar or cuboidal cells can be recognized as a basal layer lying upon the dermis, and superficially to this are layers of cells, the lowest polyhedral, the uppermost flattened, all showing prominent nuclei many of which are undergoing mitosis. Minute processes, spines, or spicules, project from the surfaces of these cells and are connected to similar spines of adjacent cells to form intercellular bridges. Hence this layer has been termed the prickle-cell layer. Pigment accumulates chiefly in this *stratum germinativum* in the form of melanin granules. The manufacture of melanin is now believed to be governed by the activities of peculiar oval cells known as melanocytes situated in the region of the basal layer of the *stratum germinativum* or between this layer and the superficial layer of the dermis. These cells contain an enzyme first identified by Bloch (1916), which oxidizes dihydroxyphenylalanine or " Dopa " to melanin, which passes through characteristic processes or dendrites running between the deeper cells of the epidermis. The dendrites run perpendicularly and laterally and some appear to join to form a syncytium, but the cells in fact remain distinct. Masson (1948) and Billingham (1948) observed club-like expansions at the ends of the terminal expansions of the dendrites. Fusiform swellings, possible collections of melanin granules, migrating along the dendrites have also been described by Staricco and Pinkus (1957). Whether melanin granules occur in the actual cells of the basal layer is still a matter of debate. Bischitz and Snell (1959) suggest that the melanin in fact occurs in both situations and that the more superficial layers of cells appear to contain less melanin because they have lost contact with the melanin-filled dendrites of the melanocytes.

The epidermis is derived from the embryonic ectoderm and is non-vascular and devoid of nervous elements. It must be remembered, however, that not only the horny parts of the claw, but also the hairs and their associated glands are epidermal in origin and these latter, having come to lie in the dermis, are well supplied with blood and are associated with the nervous system. Before we consider these elements, however, let me say a word or two about the dermis, or true skin, or corium.

THE DERMIS

The dermis is a felted network of fibres, chiefly collagenous but also elastic. It consists of two layers :

1. *The Papillary Layer or Papillary Body.* This is the thinner of the two layers and it lies superficially. It is arranged in the form of innumerable conical projections—generally not as conical in the dog as in man—upwards into the epidermis. Thus its surface shows a negative imprint of the deep face of the epidermis. It is composed of delicate collagenous and elastic fibres amongst which lie capillary loops.

2. *The Reticular Layer.* This constitutes the remainder ; it is not sharply differentiated from the papillary layer, in fact the one merges gradually into the other. But in this layer the network of fibres is looser although the fibre bundles are coarser and branching. The majority of the fibres are arranged with their long axes parallel to the surface, but a few lie more or less vertically and form a framework for collections or lobules of fat which of course varies very much in quantity in different subjects and different regions of the body. Amongst the meshes of the collagen fibres lie networks of coarse reticular fibres. In this layer lie the roots of the hairs and the various glands, and in certain regions, e.g. the teat and the scrotum, there are found bundles of smooth muscle fibres which in the former assist in erection, and in the latter wrinkle the skin. There are a certain number, not many, of fibroblasts and mast cells and, in certain conditions, histiocytes, or macrophages can be seen acting as phagocytes. Pigment-producing melanocytes are not prominent.

THE HAIRS

These are present over most parts of the body, extending some distance into the external auditary meatus, and disappearing gradually at the muco-cutaneous junctions and where the skin merges into the pads and reaches the claws. They are absent on the *planum nasale*, in the preputial cavity, on the *glans penis* and at the umbilicus. The hairs are arranged in definite tracts and the direction of the hairs in these tracts is constant. Thus the hairs of the shoulder and arm are directed towards the point of the elbow, those of the ear towards its free edge, and those of the flank are directed some forwards towards the chest wall and some backwards towards the region of the thigh. Other hairs, such as the eyelashes, the tactile hairs, and the hairs of the auditory canal, obviously have a protective function. The length of the hair varies greatly in different parts of the body, and, as we all know, some breeds carry much longer coats of hair than others, for example the Afghan hound or the corded poodle may show hairs many inches long, whilst in the so-called hairless dog of Mexico the length of the delicate lanugo hair is a matter of a few millimetres.

The hairs are epidermal in their origin, the epidermis sending down into the dermis an infolding or follicle, from the depth of which projects the hair. The hairs of the dog, however, are rarely arranged singly, as in man, for they

are collected into groups of any number up to about a dozen. Of these perhaps two or three are comparatively long and strong hairs whilst the remainder are finer and more delicate. All the hairs of the group project from a single opening but within this opening lead away the several follicles of the group, so that we find what Trautmann and Fiebiger (1949) have called a "follicle complex." At the lowest part of the hair is an enlargement—the bulb—into which projects a dermal papilla. Leading up from the bulb is the hair shaft composed of a central medulla or pith, made up, at least in the region of the bulb, of nucleated cells, which may be cuboidal, or polygonal, or flattened, containing pigment granules, together with fat and air spaces as we proceed towards the free end. Outside this is the so-called cortex consisting of keratinized cells with their long axes arranged in the direction of the length of the hair, and finally an outermost scaly cuticle composed of flat, non-nucleated, keratinized cells. The appearance of the cuticle with its overlapping scaly cells has been regarded as specific to a particular species of mammal, but Creed (1958) has drawn attention to the value of observing cells of the medulla as further confirmation of specificity.

Within the follicle, two sheaths surround the root of the hair. The outer root sheath consists of an outer glassy layer which separates the root sheath from the surrounding connective tissue sheath of the dermis, and an inner collection of cuboidal or cylindrical cells arranged in concentric layers. This is a continuation of the Malpighian layer of the epidermis. The inner root sheath can be divided into two layers, viz., an outer layer of horny, oblong, non-nucleated cells—the layer of Henle—and an inner layer of polyhedral nucleated cells—the layer of Huxley. Within this again is a cuticle of downwardly-projecting scales which fit over the upwardly-projecting scales of the hair itself.

A hair projects obliquely from the skin surface—a fact which makes the obtaining of a complete longitudinal section of a hair a somewhat wearisome, if not a difficult, task—and on the side to which it leans lies a bundle of unstriped muscle extending from a point a little above the bulb to the papillary body. This muscle, when it contracts, straightens the hair and is therefore known as the *arrector pili* muscle. It can also cause a depression of the surface so that the papillae stand out prominently as is seen in the so-called goose-flesh of man. These muscles are best developed in the mid-dorsal line of the neck and at the root of the tail.

The so-called tactile hairs projecting from the region of the lips are peculiar in more than one respect. Not only are they larger and longer than the adjacent hairs, but their massive root is enclosed in a thick-walled connective tissue sheath between the layers of which lies a venous cavity broken into irregular spaces by trabeculae. For this reason these hairs have been termed sinus hairs. The engorgement of blood here doubtless causes some erection of these hairs, but *arrectores* fibres are plentiful and some authorities claim to have observed striped muscle fibres here.

THE PADS

The flexor surfaces of the *manus* and *pes* carry modified parts of the integument which we recognize as the digital pads. In each limb there is one large pad beneath the metacarpo-phalangeal or metatarso-phalangeal joints and four (or five in the forelimb) smaller pads beneath the second interphalangeal joints. Behind the carpus there is a small pad situated medially and distally to the accessory bone. The central metacarpo-phalangeal or metatarso-phalangeal pads are shaped like the heart of a playing card with its apex below or in front. The epidermis is very well developed, both the *stratum granulosum* and the more superficial keratinized layers being very thick. The surface shows innumerable large papillae which are underlaid by correspondingly large papillae of the corium, bearing peculiar sharply-pointed processes. Beneath the corium lies a mass of fibro-elastic and fatty tissue with definite fascial bands of attachment to the tendon of the *flexor digitorum sublimis* or to its annular ligament. The digital pads are similar in structure to the metacarpo-phalangeal pads, but they are smaller and have an oval outline. They are attached to the tubercles at the distal end of the second phalanx. The pads are, of course, cushions upon which most of the weight of the body is carried when the dog stands. The carpal pad is still smaller and has a circular outline. It is attached deeply to the fascia covering the volar aspect of the carpus. The pads are devoid of hair but at their periphery the hairless horny epidermis merges with that of the adjacent hairy skin.

THE CLAWS

Each of these is roughly of the same shape as that of the third phalanx which it encloses. It may be said to consist of a horny wall and a sole. The wall is laterally compressed and is also curved from above and below. Its proximal border is thin, and it fits into the groove beneath the ungual crest of the third phalanx. Its inner surface shows small soft laminae. Its distal or ventral border surrounds the sole, often extending beyond it and sometimes enclosing it. The sole differs from the wall in that its horn is looser and more friable on its superficial surface. It carries minute tubules into which project papillae of the corium. The wall and sole are modified portions of the epidermis of the digit. The corium beneath is thick and firmly attached to the underlying bone. Corresponding to the horny laminae of the wall and the tubules of the sole are soft laminae and papillae, respectively, of the corium.

THE GLANDS OF THE SKIN

The most numerous and the most superficially situated glands are the sebaceous glands. Developing from the outer root sheath of the hair, they occur wherever there is a follicle and even in some places where hairs are absent, e.g. the depth of the auditory canal, vulva, anus and eyelids. They are multiple, acinar, branched alveolar glands, somewhat globular if the hairs are arranged

closely together, and their ducts open into the hair follicle a little below the surface. Some say that there are as many glands as there are hairs, but where, as in most regions in the dog, there are a number of hairs appearing on the surface from one follicle this seems hard to believe. The glands are of the holocrine type, i.e. their secretion consists of the whole cell, cast off from its neighbours and dead. The cells are large, those lining the acinus being polygonal and misshapen and laden with lipid droplets, whilst the peripheral cells are smaller and usually flattened. The secretion of sebaceous glands, known as sebum, is a very complex material composed of lipids and cell debris, but its composition differs as between one species and another, and possibly in different parts of the skin in the same animal. Wheatley (1953) believes that cholesterol and certain free fatty acids are the only substances which occur constantly, in all species. Melczer and Deme (1942) claim to have identified four concentric layers of lipids in human glands, these ranging from fatty acids, probably oleic acid, at the periphery, to a mixture of fatty acids, neutral fats and esters of arachyl alcohol in the most central layer. The growth of the cellular elements of sebaceous glands and the mechanism of the replacement of the central cells are matters which have given rise to considerable discussion. Some believe mitotic division occurring in the peripheral cells is responsible for a cyclic rhythm such as occurs in the surface epidermis. Others consider that the mitotic activity is confined to the epithelium in the region of the ducts and that new cells produced here pass back into the acini of the glands. Mitotic division of the peripheral cells of female mice has been shown to be correlated with the oestrous cycle, and in both sexes the glands became fully active at puberty. The familiar *acne vulgaris* of the adolescent human subject is considered to be in large measure due to the increase in size and activity of the sebaceous glands, but the cause of this increased activity is undoubtedly due to hormonal influence, and whilst testosterone and progesterone have been shown to be active agents in bringing about enlargement of the glands, it is thought that the pituitary also plays an important and independent part in the control of their activity.

Other glands found in the skin of the dog are characterized by their tubular structure. At least two varieties of these so-called tubular glands can be distinguished. The more numerous form is an apocrine gland, i.e. the secretion consists of the product of the breakdown of the superficial part of the cells lining the alveolus. The secretory portion of the gland is usually situated deep in the dermis, about the level of, or below, the hair bulb. Here the gland has the form of a coiled or tortuous tube rolled into a ball or glomus and from this the duct travels up, sometimes coiled, sometimes straight, at the side of a hair follicle—usually there is one to each follicle complex—to open into the follicular canal at the level of, or above, the openings of the ducts of the sebaceous glands. The secretory epithelium is arranged in a single layer of columnar or cuboidal cells.

Another variety of tubular gland is found only in the digital pads. Unlike the preceding type, these glands develop as downgrowths of the surface epithelium, and consequently their ducts, which are wide and lined by epithe-

PLATE I

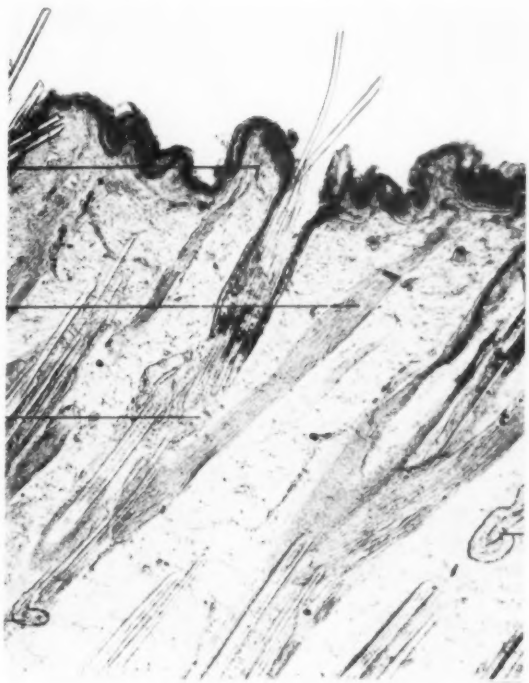


FIG. 1.—Section of skin of back. The section was made somewhat obliquely to the long axes of the hairs and consequently a number of follicles are sectioned at different levels. AP Arrectopili muscle. P Dermal papilla. S Sebaceous gland T Apocrine tubular gland.

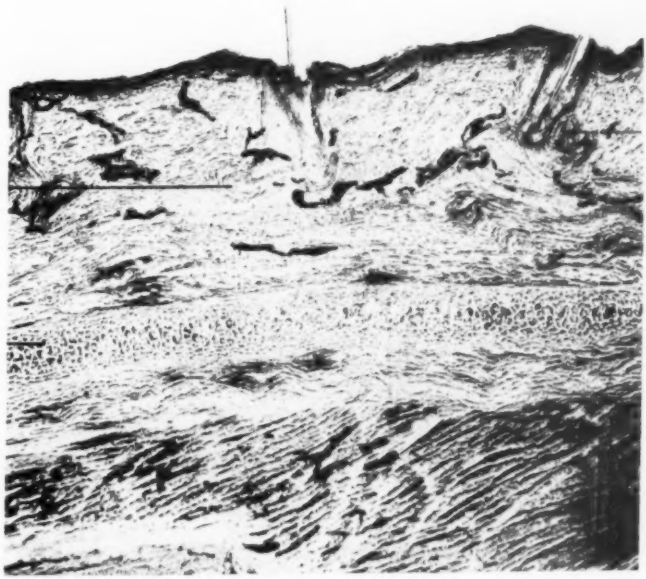


FIG. 2.—Section of skin lining the external auditory meatus showing wide but short hair follicles with associated glands. T Tubular gland. S Sebaceous gland. C Layer of cartilage. The dark areas represent injected veins.

PLATE II

FIG. 3.—Sagittal section of planum nasale showing thick epidermis. Note absence of glands. D Duct of lateral nasal gland.

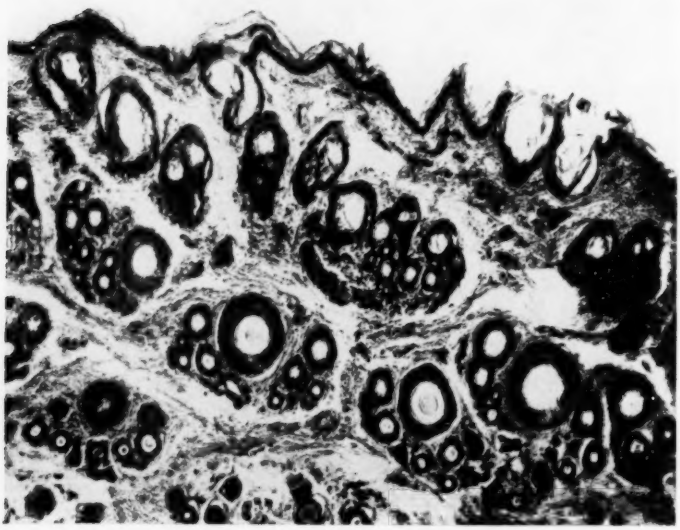


FIG. 4.—Transverse section of hair follicle complexes.

PLATE III

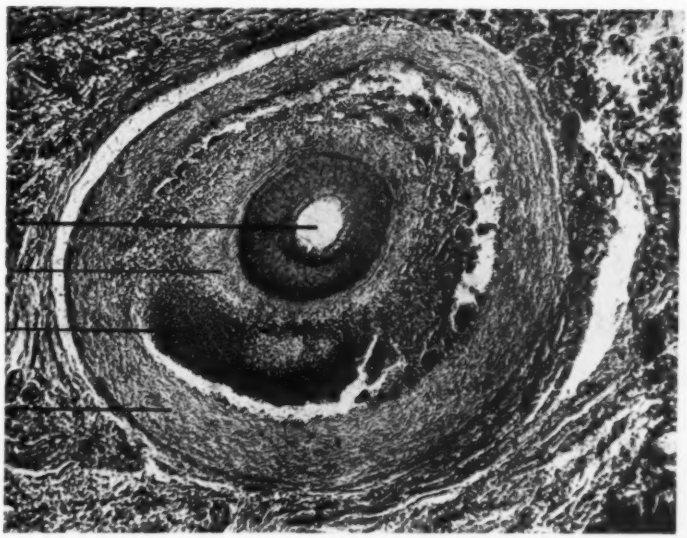


FIG. 5.—Transverse section of follicle of sinus hair. B Blood in sinus. M Medulla of hair. So Outer layer of connective tissue sheath. Si Inner layer of connective tissue sheath.

FIG. 6. Sagittal section of claw.

PLATE IV

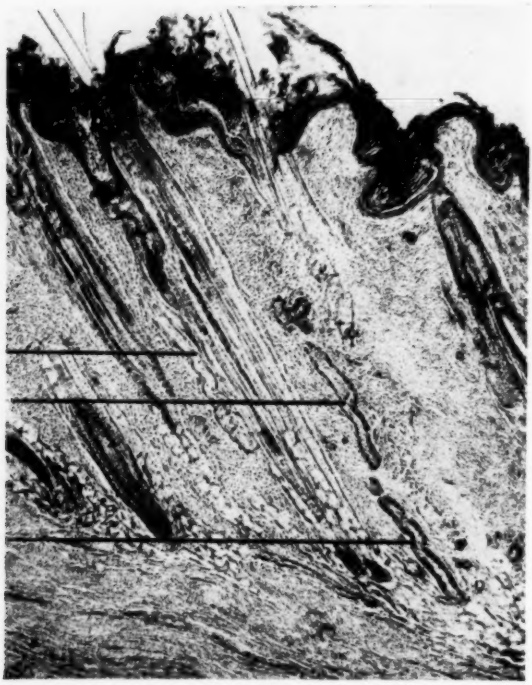


FIG. 7.—Section of skin showing T tubular apocrine glands.

FIG. 8.—Vertical section of digital pad showing thick epidermal layers and branching dermal papillae. DL Longitudinal section of merocrine tubular glands. DT Transverse section of merocrine tubular glands. P Dermal papilla.

lium which is often pigmented, open on the surface of the pads between the papillae. The glands are of the merocrine type, the watery secretion leaving the epithelium undamaged.

The structure of these two kinds of tubular glands appears to be very similar. A layer of large columnar cells with light nuclei surrounds the lumen of the gland, whilst outside this is a layer of smaller, flatter cells showing darkly stained nuclei which are probably myoepithelial cells. These latter are better developed in the apocrine glands.

These two varieties of tubular gland have been termed sweat glands, but whereas in man the clear watery sweat, which we recognize as being largely responsible for heat regulation, is produced as a true secretion by the merocrine or eccrine glands scattered all over the surface of the body, in the dog their counterparts are situated only in the pads. The apocrine glands on the other hand, found in man only in certain regions, such as the axilla and the external genitals, are distributed in the dog throughout the whole of the integument. The function of these tubular glands is a matter of uncertainty both in man and domestic mammals. Aoki and Wada (1951) showed that the apocrine glands of the dog's skin respond equally to intradermally injected pilocarpine, acetylcholine and epinephrine in normal or excised skin, and they therefore concluded that these glands have a dual innervation of cholinergic and adrenergic fibres. So far as the apocrine glands of man are concerned this has been denied by Shelley and Hurley (1952) who recognize in man only an adrenergic innervation, but Rothman (1954) and others suggest that the glands may have a dual function in accordance with their dual innervation, and that the adrenergic stimulus, perhaps of the myoepithelial cells, produces the expulsion of milky droplets, whereas the cholinergic innervation is responsible for the secretion of more fluid sweat. But knowing, as we do, that the dog does not in fact reveal much fluid sweat over the greater part of the body, may it not be that these so-called apocrine glands are in fact composite structures and that the development of their component parts varies in different species? Or, are there varieties of tubular glands scattered over the surface of the body? As Creed (1958) has said, "Evidently the 'sweat' of the dog and of other mammals has only one common factor—that it is produced by the tubular glands of the skin." One should add that the apocrine glands are known to be responsible for the secretion of odorous substances which appear to be not only species specific, but also sex-specific, and thus they play an important part in the sex life of the dog.

THE BLOOD SUPPLY

With regard to the blood supply to the skin, we are accustomed to seeing large vessels, particularly veins, lying immediately beneath the integument. Branches or tributaries of these can often be traced entering or leaving the deeper layers of the subcutaneous fascia. It has been found (Hughes and Dransfield, 1959) that there is little constant pattern in the arrangement of these macroscopic vessels beyond the fact that in the trunk over the wall of the thorax they are arranged segmentally, each corresponding to an embryonic dermatome, with,

it should be added, not a little irregularity even in this pattern in that one vessel may take over some of the function of the vessel adjacent.

In the microscopic arrangement of the cutaneous vessels, however, a much more regular pattern is evident, as was first demonstrated by Spalteholtz (1893). He described three quite distinct but intercommunicating plexuses of arteries and veins—superficial, middle and deep.

Dealing first with the arterial plexuses, the deep or fascial subcutaneous plexus consists of small arteries, many apparent to the naked eye, running in the superficial fascia and in the deeper layer of the dermis. Where a sheet of

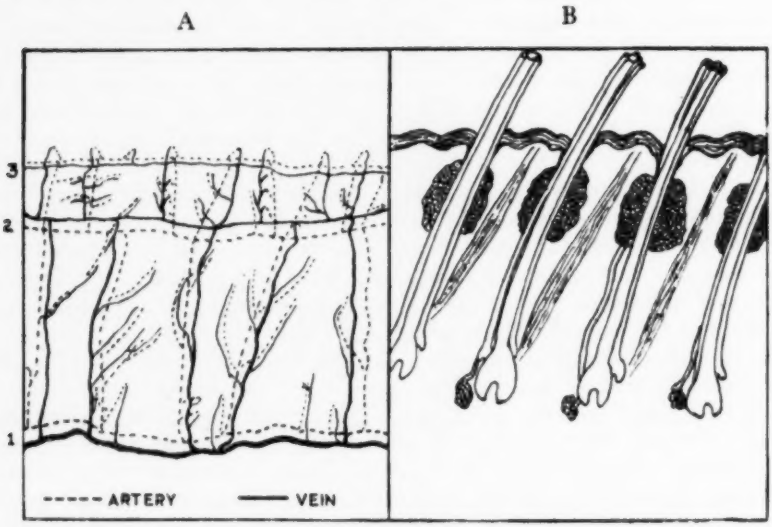


FIG. 9.—Diagram of vertical section of skin showing. A The arrangement of the blood vessels. 1, 2 and 3 Deep, middle and superficial plexuses respectively. B The main structural elements.

the cutaneous muscle underlies the skin, the vessels are seen to lie on either side of it and to supply it by means of branches running largely in the direction of the muscle bundles. From this plexus branches run to supply the fatty tissue and others pass superficially in the direction of the length of the hair to supply its bulb and the deeper part of the follicle and the adjacent tubular gland. These vessels, or others passing more directly from the plexus, continue upwards to become the radicles of the middle plexus.

The middle layer plexus lies immediately below or at the level of the sebaceous glands. From it ascending and descending branches arise. The larger descending branches are the direct communications with the fascial plexus just mentioned, but others run to join in the capillary plexus which supplies the lower part of the hair follicles and *arrectores* muscles together with the adjacent glands. Many of the ascending branches divide into capillaries to form a plexus supplying the superficial part of the hair follicle and its

associated sebaceous glands and tubular gland ducts, but some pass upwards to become radicles of the superficial plexus.

The superficial plexus is situated in the superficial layers of the dermis, i.e. at the level of the bases of the dermal papillae. It is fed from below by the ascending branches of the middle plexus, and from it run capillary loops into the papillae. The size and number of these loops, of course, varies greatly, depending upon the development of the dermal papillae.

Such is the general arrangement of the smallest arteries in the dermis, but pecularities of structure in certain regions of the body, such as the prepuce and scrotum, the teat, the ear, and eyelid, together with the mucoc-utaneous junctions, result, as might be expected, in some slight variations in the arrangement. Generally speaking, the veins follow the courses of the arteries and there are three venous plexuses corresponding in position to the three arterial plexuses.

THE INNERVATION OF THE SKIN

I mentioned earlier that the skin was capable of mediating the four sensations of heat, cold, pain and touch. For each of these modalities of sensation there are sensitive or sensory spots scattered all over the body and it has long been thought that each possessed its own peculiar nerve endings. The work of Hagen, Knoche, Sinclair and Weddell (1953), however, has cast doubt upon some of the older conceptions regarding the function of end organs in the skin of man and animals, and it appears that a reappraisal of the histology of the nervous elements in the integument is now required. Because of this and for the very good reason that I have no personal knowledge of the problem of the innervation of the skin of the dog, I beg leave to let the matter rest here.

In this very cursory description of some of the more obvious elements which go to make up the skin of the dog I am fully aware that I have merely touched the fringe of this enormous subject. During the last two decades human dermatology has made very considerable strides, and in particular the fundamental aspects of the anatomy, physiology, and biochemistry of skin have been studied to a degree which is quite remarkable. Yet it would appear that the study of the skin of our domestic animals has not made commensurate progress. I can but hope that what I have said may in some small degree help to stimulate interest in the subject.

REFERENCES

Aoki, T. & Wada, M. (1951) : *Science*, **114**, 123–127.
Billingham, R. E. (1948) : *J. Anat.*, **82**, 93–109.
Bischitz, P. G. & Snell, R. S. (1959) : *J. Anat.*, **93**, 233–245.
Bloch, B. (1916) : *Z. physiol. Chem.*, **98**, 226–254.
Creed, R. F. S. (1958) : *Vet. Rec.*, **70**, 174.
Hagen, E., Knoche, H., Sinclair, D. C. & Weddell, G. (1953) : *Proc. roy. Soc. B*, **141**, 279–287.
Hughes, H. V. & Dransfield, J. W. (1959) : *Brit. vet. J.* **115**, 299.
Masson, P. (1948) : *The Biology of Melanomas*, Ed. Miner, R.W. New York Academy of Sciences.
Melczer, N. & Deme, S. (1942) : *Dermatologica*, **86**, 24–36.
Rothman, S. (1954) : *Physiology and Biochemistry of the Skin*. University of Chicago Press.
Shelley, W. B. & Hurley, H. J. (1952) : *Arch. Derm. Syph.*, **66**, 156–161.
Spalteholz, W. (1893) : *Arch. Anat. Physiol.*
Staricco, R. J. & Pinkus, H. (1957) : *J. invest. Derm.*, **28**, 33–45.
Trautmann, A. & Fiebiger, J. (1949) : *Fundamentals of the Histology of Domestic Animals*, 8th & 9th ed., transl. Habel, R. E. & Biberstein, E. L. (1952). London : Bailliere, Tindall and Cox.
Wheatley, V. R. (1953) : *St. Bart's Hosp. J.*, **57**, 5–9.

REVIEWS

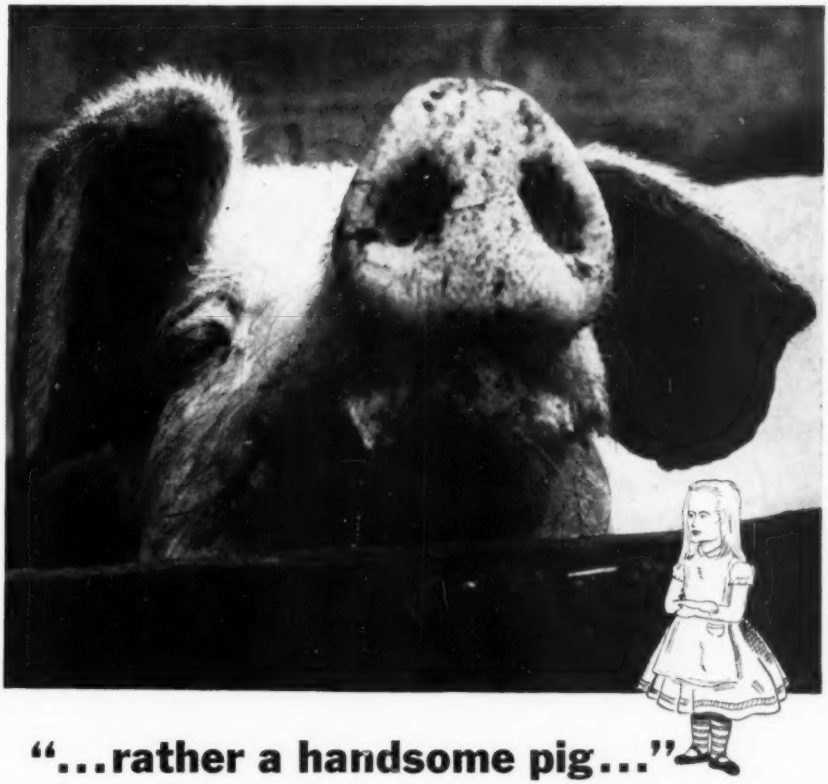
Achievement : Some Contributions of Animal Experiment to the Conquest of Disease
By GEOFFREY LAPAGE, pp. 255. Cambridge : Heffer. 18s.

The scientific texts by Dr. Lapage covering parasitology are internationally known. Not so well known perhaps are his other literary ventures in short books dealing with parasites, and I seem to remember he once published a book of verse—" The Flight of the Goslings," also published by Heffer. Whatever he has written in the past has been done with literary grace and erudition ; you might not always agree with what he says but you will never be bored. His versatility is a talent to be admired, and there are not all that number of scientists who possess his ability to write in impeccable English the way he does.

The present compilation is a short book covering a great vista of things. The aim is " to state as simply and clearly as a writer can, what happens when scientists do experiments on living animals . . . . and some, at any rate, of the benefits to man and animals that these experiments have conferred." The moral aspects of animal experimentation is left to the reader's judgment. Yet, every page is high documentary evidence of the inescapable necessity in medical, veterinary, and biological research to use animals—with all humane consideration. My own feeling is that this latter theme could have been the sole goal.

To anyone interested in the history of medicine in general, or in the sciences which specifically deal with the nature of diseases and their causations, and then their control, the book cannot help but have an appeal. Pay no attention to those who think that an interest in the history of medicine is a sign of oncoming senility—an accusation once levelled at myself 20 years ago. In effect, the book is an abridged but special history of medicine, related to man's effort to control disease in man and animals. So, the approach, chapter by chapter, is by the broad categories of causes of diseases—bacterial, rickettsial, viral, protozoal and helminthic, chemicals and hormones. Thereafter comes a chapter on surgery, one on foods and vitamins and one on dieases of domesticated animals. In view of his lifelong interest in parasitic worms, it is a little surprising, that so little attention is devoted to helminthology. So, inevitably, the big discoveries and the men who made the animal experiments, and how they were made, are paraded before us. To anyone of maturity in veterinary or human medicine, all these facts will have been acquired many years ago.

No grumble can be made with the approach, the style or the facts presented, whether the author is dealing with insulin, chloroform, sulphonamides, penicillin, vitamins, bacteria or viruses. In a careful reading, I could not find a single error or misrepresentation of historical fact. Doubtless, very many qualified medical and veterinary workers do not know, or are not interested in the history presented, and much could be learned by them through perusal of this book. The query that arises in my mind concerns exactly what type of audience the author had in mind in writing the book. For the expert, there are a plethora of authoritative texts in English alone on the history of medicine (also anatomy, embryology, bacteriology)—Garrison, Major, Mettler, Singer, Needham and so on. For those who wish less details



"...rather a handsome pig..."

". . . so she set the little creature down and felt relieved to see it trot away quietly into the wood." "If it had grown up," she said to herself, "it would have made a dreadfully ugly child; but it makes rather a handsome pig, I think." And she began thinking over other children she knew, who might do well as pigs, and was just saying to herself, "If one only knew the right way to change them—"

ALICE IN WONDERLAND—LEWIS CARROLL.

The changing of children to pigs doesn't concern us but we *are* interested in the "handsome pig." The secret of changing anaemic pigs into healthy, blooming, thriving pigs is . . . Imposil.

Imposil contains 150 mg. of iron in every 2 c.c. injection. One injection, given to the piglet on the third day of life, ensures that a piglet is fully protected from iron deficiency for the vital first four weeks of life.

Imposil is available from Veterinary wholesalers in 20 c.c. vials (10 doses) at 16/8d. and 50 c.c. vials (25 doses) at 40/-.

Imposil

TRADE MARK BRAND OF FERRIMICRODEX

BENGER BENGER LABORATORIES LIMITED · HOLMES CHAPEL · CHESHIRE

144

'PERMACO' Cobalt Bullets

Increase weight gain

by correcting VITAMIN B_{12} deficiency

Cobalt is well recognised as an essential trace element for ruminant animals. It is utilised by the micro-flora of the rumen and reticulum for the production of Vitamin B_{12}, of which an adequate supply is essential for optimum growth and production. When cobalt is not available in sufficient quantity in the pasture, it can be provided more conveniently, cheaply and effectively by 'Permaco' Cobalt Bullets than by any other method of administration to large numbers of grazing animals. Cobalt bullets, applied by oesophageal balling gun, lodge in the rumeno-reticular sac for a long period, during which they continuously release cobalt in sufficient quantity for therapeutic or prophylactic purposes.

Trial proves 'PERMACO'S' biological efficiency

Australian experiments involving 246 cattle on pasture known, or suspected, to be deficient in cobalt, showed that a single treatment with a 20 gm. cobalt bullet effectively corrected clinical or sub-clinical cobalt deficiency.

In one of these trials, conducted on King Island, 22 dairy Shorthorn yearling heifers were treated with a cobalt bullet and the concentration of Vitamin B_{12} in the liver was thereby increased. This showed a positive correlation with increased weight gain. +

	CONTROL ANIMALS		TREATED ANIMALS	
Months after Treatment	*Average Wt. (lbs)*	*Average Liver Vit. B12 (ug/gm)*	*Average Wt. (lbs)*	*Average Liver Vit. B12 (ug/gm)*
0	283	0.07	283	0.07
2	277	—*	279	—*
4	305	0.29	334	0.53
6	441	0.25	475	0.47

* *Liver Vitamin B12 not estimated.*

REFERENCE + *Sherman, K. D., Sutherland, A. K., O'Halloran, M. W., Bourke, J. M., and Munday, B. L., (1959), Am. J. Vet. Res., XX, 977.*

Nicholas
'PERMACO'
SI-RO-CO COBALT BULLETS

ONE-DOSE TREATMENT FOR CATTLE

A NICHOLAS N PRODUCT

Cobalt Bullets for sheep and cattle are manufactured in the U.K. solely by
ASPRO-NICHOLAS LIMITED · VETERINARY DIVISION · SLOUGH · BUCKS
Manufacturers of Nicholas 'Paratac' and 'Hexapour' Liver Fluke Drench

but still to cover the ground there is Guthrie. For the intelligent lay public there is an equally large number of highly successful books—sometimes a little too melodramatic and lurid. To some extent therefore, I have a feeling the book falls into a sort of halfway class. It contains far too much technical details to be appreciated by those outside human or veterinary medicine, and not enough for those who know. There is nevertheless an admiration in my mind for the way the book has been assembled and written, for an immense amount of reading would be necessary to cover the diverse fields of science, all outside the author's own personal main interests in parasitology. Only a medical worker with a long association with a veterinary institution could deal with diseases of domesticated animals in such a familiar fashion. The book can be highly recommended, but possibly only to a certain class of reader. Perhaps this is the type of presentation which should be required reading for veterinary and medical students, as soon as they have finished with anatomy and physiology, and before proceeding to the study of pathology and bacteriology. This would give them a very much needed re-orientation of what, in broad terms, all that is come means. It will bring forth to them that wisdom was not born with us in 1960, that mixed with the brilliant endeavours of our scientific ancestors there was folly, and that it takes a long time before problems connected with diseases are solved—if ever they are solved.

At the end of the book there is an appendix containing an explanation of the legal control of experiments on living animals in Britain. This is the first time I have seen it so clearly stated in print, nor did I know that the movement was started first as a result of veterinary representation. To American readers, this part may be of interest, because the facts are frequently misunderstood and misquoted. As I have often explained in the U.S.A., there is nothing wrong with the British system, only everything to be admired, nor has it ever hindered research and the work of men like Sherrington, Barcroft, Hopkins, Florey, could not have been bettered merely because they had unlimited licence to perform experiments on animals. That has been suggested in the U.S.A. The value of the second part of the appendix, because of its brevity, is doubtful.

The job of the reviewer is not done until he makes some criticism or other. We all possess some faults in writing, and I must say I winced a little at the repetition of the phrases " as so- and so- explained or stated." Second, no matter what kind of history of medicine is written, I fail to see how Virchow can be omitted—for his discovery was the greatest since the discovery of the circulation of the blood by Harvey. By the stroke of the pen, he took medicine out of the dark ages, and made possible the modern approach in pathology, clinical medicine, and the " ætiologic sciences."

The book is well printed, the index adequate, the price reasonable, and the list of references at the end is useful. Congratulations, Dr. Lapage.

J. R. M. Innes.

NEWS

UNIVERSITY OF BRISTOL

It is announced that Professor T. K. Ewer has been appointed to the newly established chair of Animal Husbandry in the University of Bristol.

Professor Ewer was born in Cornwall and at the age of 17 emigrated to Australia. There he went as a scholar to the Hawkesbury Agricultural College, obtained its Diploma with honours and went on to the University of Sydney, graduating as B.V.Sc. in 1937. Thereafter he worked in New Zealand, gathered wide experience in diagnostic work and in animal production problems generally, finally becoming Senior Lecturer in Veterinary Science at Canterbury Agricultural College.

In 1947 he spent three years as a Wellcome Research Fellow at what was then the Institute of Animal Pathology, Cambridge, and proceeded to the Ph.D. degree following studies on the relationship between vitamin D and mineral metabolism in sheep.

After this, in 1949, he was appointed to the first chair of Animal Husbandry in Australia at the University of Queensland and was Dean of the Faculty of Veterinary Science for 1950-55. The development of the faculty and the re-establishment of courses have been in large measure due to his efforts. Later he was advisor in animal production to the Venezuelan and the Burmese governments for F.A.O. and has been active in many fields of agricultural and educational work in the State of Queensland and in Australia generally.

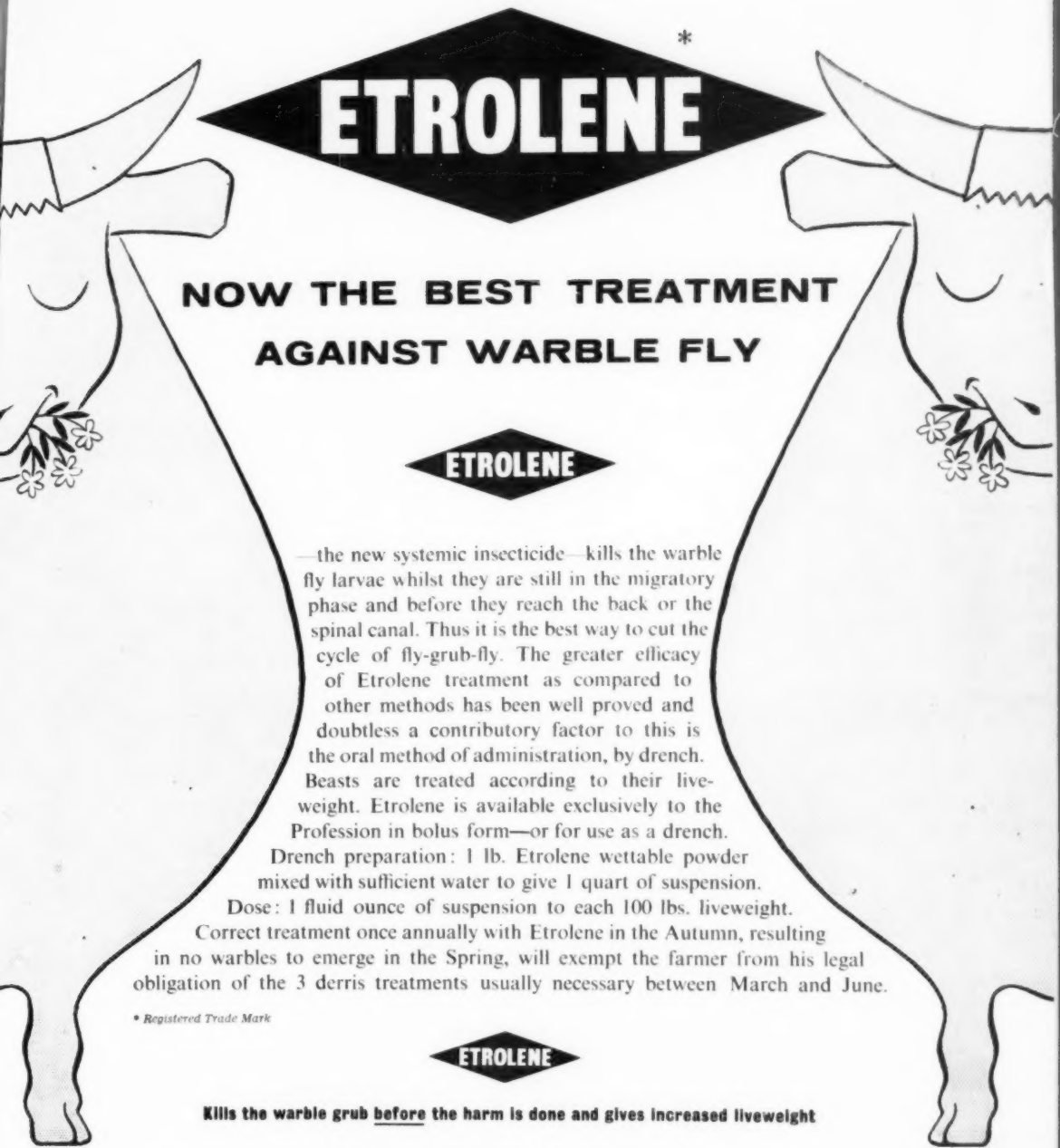
It is a pleasure to welcome back to the veterinary profession in England someone with such wide experience and one who can contribute so much to veterinary education and the solution of problems in animal husbandry.

TRADE ANNOUNCEMENTS

Smith & Nephew Pharmaceuticals Ltd. announce the introduction of Narphen veterinary brand phenazocine hydrobromide, a new synthetic analgesic which is said to be more powerful than morphine or pethidene.

Narphen may be administered intravenously or intramuscularly in the dog, to produce analgesia, without the side effects often attendant upon the use of morphine.

Narphen is subject to the Dangerous Drugs Regulations and is available in ampoules containing 2 mg. phenazocine hydrobromide per ml. aqueous solution in boxes of 10 and 100 1.1 ml. ampoules.



ETROLENE*

NOW THE BEST TREATMENT AGAINST WARBLE FLY

ETROLENE

—the new systemic insecticide—kills the warble fly larvae whilst they are still in the migratory phase and before they reach the back or the spinal canal. Thus it is the best way to cut the cycle of fly-grub-fly. The greater efficacy of Etrolene treatment as compared to other methods has been well proved and doubtless a contributory factor to this is the oral method of administration, by drench. Beasts are treated according to their live-weight. Etrolene is available exclusively to the Profession in bolus form—or for use as a drench.

Drench preparation: 1 lb. Etrolene wettable powder mixed with sufficient water to give 1 quart of suspension.

Dose: 1 fluid ounce of suspension to each 100 lbs. liveweight.

Correct treatment once annually with Etrolene in the Autumn, resulting in no warbles to emerge in the Spring, will exempt the farmer from his legal obligation of the 3 derris treatments usually necessary between March and June.

* *Registered Trade Mark*

ETROLENE

Kills the warble grub before the harm is done and gives increased liveweight

For technical information write to Dr. W. E. Ripper

DOW AGROCHEMICALS LTD.
KING'S LYNN, NORFOLK
Telephone: King's Lynn 5141

NEWS

UNIVERSITY OF BRISTOL

It is announced that Professor T. K. Ewer has been appointed to the newly established chair of Animal Husbandry in the University of Bristol.

Professor Ewer was born in Cornwall and at the age of 17 emigrated to Australia. There he went as a scholar to the Hawkesbury Agricultural College, obtained its Diploma with honours and went on to the University of Sydney, graduating as B.V.Sc. in 1937. Thereafter he worked in New Zealand, gathered wide experience in diagnostic work and in animal production problems generally, finally becoming Senior Lecturer in Veterinary Science at Canterbury Agricultural College.

In 1947 he spent three years as a Wellcome Research Fellow at what was then the Institute of Animal Pathology, Cambridge, and proceeded to the Ph.D. degree following studies on the relationship between vitamin D and mineral metabolism in sheep.

After this, in 1949, he was appointed to the first chair of Animal Husbandry in Australia at the University of Queensland and was Dean of the Faculty of Veterinary Science for 1950-55. The development of the faculty and the re-establishment of courses have been in large measure due to his efforts. Later he was advisor in animal production to the Venezuelan and the Burmese governments for F.A.O. and has been active in many fields of agricultural and educational work in the State of Queensland and in Australia generally.

It is a pleasure to welcome back to the veterinary profession in England someone with such wide experience and one who can contribute so much to veterinary education and the solution of problems in animal husbandry.

TRADE ANNOUNCEMENTS

Smith & Nephew Pharmaceuticals Ltd. announce the introduction of Narphen veterinary brand phenazocine hydrobromide, a new synthetic analgesic which is said to be more powerful than morphine or pethidene.

Narphen may be administered intravenously or intramuscularly in the dog, to produce analgesia, without the side effects often attendant upon the use of morphine.

Narphen is subject to the Dangerous Drugs Regulations and is available in ampoules containing 2 mg. phenazocine hydrobromide per ml. aqueous solution in boxes of 10 and 100 1.1 ml. ampoules.

ETROLENE*

NOW THE BEST TREATMENT AGAINST WARBLE FLY

ETROLENE

—the new systemic insecticide—kills the warble fly larvae whilst they are still in the migratory phase and before they reach the back or the spinal canal. Thus it is the best way to cut the cycle of fly-grub-fly. The greater efficacy of Etrolene treatment as compared to other methods has been well proved and doubtless a contributory factor to this is the oral method of administration, by drench. Beasts are treated according to their live-weight. Etrolene is available exclusively to the Profession in bolus form—or for use as a drench.

Drench preparation: 1 lb. Etrolene wettable powder mixed with sufficient water to give 1 quart of suspension.

Dose: 1 fluid ounce of suspension to each 100 lbs. liveweight.

Correct treatment once annually with Etrolene in the Autumn, resulting in no warbles to emerge in the Spring, will exempt the farmer from his legal obligation of the 3 derris treatments usually necessary between March and June.

* *Registered Trade Mark*

ETROLENE

Kills the warble grub before the harm is done and gives increased liveweight

For technical information write to Dr. W. E. Ripper

DOW AGROCHEMICALS LTD.
KING'S LYNN, NORFOLK
Telephone: King's Lynn 5141

AEROSOL 356

for the treatment of ringworm and other mycotic infections. AEROSOL 356 contains dichlorophen and an antiseptic agent.

ODOUR SUPPRESSANT AEROSOL

will mask the characteristic odour of bitches "in season," and prevent the undesirable attentions of male dogs. ODOUR SUPPRESSANT AEROSOL is also a pleasant and effective air freshener, and may be used in kennels and surgeries.

Both products available in cartons of 6 or 12 units.

Prices and literature on request

SOMERSET PHARMACEUTICALS LTD.

WELLINGTON. SOMERSET

Telephone: Wellington, Somerset 2244

ANIMAL BEHAVIOUR

Editor : Alastair N. Worden

This **journal** formerly the **British Journal of Animal Behaviour** is now greatly enlarged and issued twice a year in March and September.

The Journal publishes original papers on animal behaviour and allied subjects from contributors in many countries, including a large proportion from the U.S.A.

Reports of researches, reviews, correspondence, and the Proceedings of the Association and of the Section of Animal Behaviour are also included.

Contents of the current issue include:

The Inheritance of Patterns in Sexual Behaviour in Female Guinea Pigs.
R. W. Goy and Jacqueline S. Jakway.

Mother-Young and the Maturation of Pup Behaviour in the Alaska Fur Seal.
G. A. Bartholomew.

The Incidence of the Following Responses and the Duration of Responsiveness in Domestic Fowl.
E. A. Salzen and W. Sluckin.

The Effect of Early Social Experience on Male Sexual Behaviour of Androgen Injected Turkeys.
M. W. Schein and E. B. Hale.

Directional Differences in Pigeon Homing in Sacramento, California, and Cedar Rapids, Iowa.
L. C. Graue and J. G. Pratt.

Territorial Rank in Starlings.
D. E. Davis.

Development of Nesting Behaviour in the Siamese Fighting Fish *Betta splendens*.
J. C. Braddock and Zora I. Braddock.

Annual Subscription 50s., U.S.A. & Canada $8.00

BAILLIÈRE, TINDALL & COX
7 & 8, HENRIETTA STREET, LONDON, W.C.2

COLD STERILIZATION

GOMAXIDE LIQUID GERMICIDE

- RIDEAL WALKER COEFF 6·5
- CHICK MARTIN COEFF 1·7

Available as follows :—
4oz. 8oz. and 1 gallon containers.

- WILL **NOT** CORRODE your finest metal instruments.
- IS NON-TOXIC, NON-CAUSTIC, & NON-IRRITANT.
- DOES NOT STAIN.
- IS SAFE regardless of the strength in which it is used.
- STERILIZATION of non-boilable instruments ; Plastic, Rubber and Cutting instruments.
- HAS POWERFUL DEODORANT PROPERTIES.
  Contains chemically pure CHLOROPHYLL.
- ECONOMICAL, because it retains its efficiency under high dilution.

The British Veterinary Journal says : "Gomaxide Liquid Germicide, which whilst being extremely efficient in action, has the merit of being very economica in use. It is non toxic, non irritant and it does not stain. It can be used to sterilize instruments and it does not corrode metals.

It is pleasant to use and it has considerable deodorant properties because it contains Chlorophyll. Gomaxide has been incorporated in an antiseptic cream which has given good results in the treatment of wound and infected skin lesions."

For al animal SKIN affections, use its companion

GOMAXINE Antiseptic Cream

- *NON-GREASY, NON-TOXIC, AFFORDING RAPID HEALING*

— Available in 1½ oz Tubes and 1 lb. Jars. —

MANUFACTURED BY GOMAX LTD

SOLE DISTRIBUTORS—

RIDDELL PRODUCTS LIMITED

'Riddell House,' 10/14, Dunbridge Street, London, E.2.

Obtainable from ARNOLD & SONS . 54 WIGMORE ST. LONDON, W.1.

TENNANTS
VETERINARY MAGNESIA

CALCINED MAGNESITE 87% MgO MINIMUM

TENNANTS (LANCASHIRE) LTD
Hazelbottom Road, Cheetham, Manchester, 8
Telephone : Collyhurst 4454 (4 lines)

WELSLIPS
WORN INSIDE WELLINGTONS

Ensure
WARM — DRY FEET

★ Welslips are a must for all wearers of rubber boots. The new 3 in one slippers which mould themselves to the feet. The ideal hygenic footwear, for shooting, fishing, or general estate work, recommended by everybody who wears them, we have thousands of testimonials.

★ Always wear Welslips inside your Wellingtons to keep your feet dry and healthy.
LADIES' AND GENTS' in all leather 9/3 inc. Tax or in soft cosy warm sheepskin 14/- inc. Tax.

★ Please state your shoe size, not your Wellington size. Please add 9d. per pair for Post/Packing. From Wellington Retailers or direct from the Sole Manufacturers.

WELLINGTON SLIPPER CO. LTD., HARWICH, ESSEX

ANIMAL PRODUCTION

Journal of the British Society of Animal Production
Contents of Volume 2, Part 2, September, 1960

CRICHTON, AITKEN and BOYNE. The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle. III. Milk, butterfat and solids-not-fat production during the first three lactations with associated live weight changes, and feed costs to first calving.

HOLMES and OSMAN. The feed intake of grazing cattle. I. Feed intake of dairy cows on strip and free grazing.

WIENER. Factors influencing average milk yield of herds at two levels of production.

BARBER, BRAUDE, HOSKING and MITCHELL. Studies on liquid skim milk for growing pigs. The effect of its abrupt removal from the diet and of supplementation with copper sulphate or amino acids.

ROBERTSON, O'CONNOR and EDWARDS. Progeny testing dairy bulls at different management levels.

PRESTON, NDUMBE, WHITELAW and CHARLESON. The effect of partial replacement of groundnut meal by white-fish meal in the diet of early-weaned calves.

LAMMING, STOKES and HORSPOOL. The influence in growth rate and slaughter characteristics of implanting fattening male hoggets with various levels of hexoestrol and diethylstilboestrol.

GATHERIUM, HARRINGTON and POMEROY. Preliminary studies of eye judgments of the gammons of bacon pigs in relation to dissection data.

ARNOLD. Harness for the total collection of faeces from grazing ewe and wether sheep.

HODGES, O'CONNOR and CLARK. The size of dairy heifers.

OSINSKA and KIELANOWSKI. Relationship between meat colour and feed efficiency in pigs.

This journal is a continuation and expansion of the *Proceedings of the British Society of Animal Production* (1944-58), and has appeared in volumes of two parts, but in order to make provision for the increasing flow of material submitted for publication, **it will in future, commencing with Volume 3 (1961), appear in annual volumes of three parts** in February, June and October. **The annual subscription will be 45s. ($7.50 in U.S.A. and Canada),** single parts 17s. 6d. ($2.75 in U.S.A. and Canada) net. Orders and subscriptions should be sent to:—

OLIVER AND BOYD LTD.
Tweeddale Court, 14 High Street, Edinburgh, 1.

One Jump Ahead...

in racing and breeding performances with **BIOGLAN** natural vitamin **E**

Bioglan Natural Vita-E Succinate has proved its outstanding value after 12 years' extensive clinical trial. Vitamin E is an essential food element, and Bioglan Vita-E Succinate provides vitamin E in its *natural* and most effective form. Animals respond with increased stamina and improved racing performance, because only Vita-E assures complete absorption, thus preventing cramp and fatigue by providing more oxygen in the tissues. Bioglan Vita-E is safe, easily administered, and invaluable in promoting fertility and breeding averages.

BIOGLAN LABORATORIES LTD

(VETERINARY DIVISION) HERTFORD, HERTS.
'Phone : CUFFLEY 2137

REPUBLIC OF IRELAND
Webber Pharmaceuticals (Ireland) Ltd., 58 Harcourt Street, Dublin.

CANADA
Webber Pharmaceuticals Ltd., 393 Weston Road, Toronto.

U.S.A.
Testagar & Co. Inc., 1354 W. Lafayette Boulevard, Detroit, 26, Mich.

Nutricon Tablets

TABLETS OF VITAMINS WITH PROTEOLYSED LIVER

A nutritional supplement for regular administration especially to the growing animal, or in increased dosage to the pregnant and lactating animal, or where signs of nutritional deficiency are apparent.

Each tablet contains:

Thiamine (*Aneurin. HCl. Vitamin B_1*)	130 I.U.	Vitamin A	500 I.U.
Riboflavin (*Vitamin B_2*)	0.75 mg.	Vitamin D	250 I.U.
Nicotinic Acid (*Niacin*)	2.5 mg.	Vitamin E (*α-Tocopheryl Acetate*) ...	0.25 mg.
Calcium Pantothenate	1.0 mg.	Vitamin B_{12} (*Cyanocobalamin*) ...	1.0 μg.
Pyridoxine (*Vitamin B_6*)	0.2 mg.	Proteolysed Liver	20.0 mg.

Available only to the Veterinary Profession or to Scientific Institutions, in bottles of 1,000 tablets. *Samples may be obtained from*

THE VETERINARY DIVISION OF BOB MARTIN LIMITED, SOUTHPORT

ANTHONY
Diseases of the Pig
4th Ed. 25s.

BENESCH & WRIGHT
Veterinary Obstetrics
50s.

BANHAM'S
Veterinary Surgeon's Vade Mecum
8th Ed. 17s. 6d.

BLOOD & HENDERSON
Veterinary Medicine
84s.

BLOUNT
Hen Batteries
15s.

COFFIN
Manual of Veterinary Clinical Pathology
3rd Ed. 45s.

DAYKIN
Veterinary Applied Pharmacology and Therapeutics
55s.

DOLLAR'S
Veterinary Surgery
4th Ed. 42s.

DUKE'S
Physiology of Domestic Animals
7th Ed. 80s.

GAIGER & DAVIES'
Veterinary Pathology and Bacteriology
4th Ed. 42s.

GARNER
Veterinary Toxicology
(formerly Lander's Veterinary Toxicology)
35s.

B.V.A. Meeting
STAND 12

HARROP:

Reproduction in the Dog

By A. E. Harrop, M.R.C.V.S.

Senior Lecturer,
Department of Animal Husbandry,
Royal Veterinary College

with five contributors

A new, authoritative and practical book on canine reproduction for veterinary practitioners, research workers and dog breeders. Hitherto there has existed in the English language no comprehensive book on the subject, and the available literature has been both sparse and scattered. Here for the first time, in language that is clear, intelligible and not too technical, is a book covering all the essential ground with business-like brevity. The book deals with anatomy and physiology of reproduction and the histology of the reproductive organs, mating, including artificial insemination—a subject in which Mr. Harrop has done a great deal of pioneer work — pregnancy, normal and abnormal labour, canine paediatrics, the effect of nutrition on reproduction, infertility in the bitch and the dog.

References to the literature are included and there are a large number of illustration including microphotographs of histological sections and a remarkable series of photographs of a whelping bitch and her puppies.

215 pp., 4 tables, 74 illustrations.

Price 30s., postage 1s. 9d.

Bailliere Tindall & Cox

B.V.A. Meeting
STAND 12

BLOOD & HENDERSON

Veterinary Medicine

By D. C. Blood, B.V.Sc.

Professor of Medicine and Surgery, Ontario Veterinary College

and J. A. Henderson, M.S., D.V.M.

Professor and Head of Department of Medicine and Surgery, Ontario Veterinary College

This is a new major textbook written primarily for veterinary students, but which will also be of value to practising veterinary surgeons. It is a comprehensive work covering fully the diseases of farm animals; but excluding small animal and poultry medicine.

The book is arranged in two sections of approximately equal size: the first, on General Medicine, deals with the general principles of diseases as they affect individual organs and systems, and the second, on Special Medicine, discusses specific diseases and conditions. Thus the reader, having first studied the general account of a disease such as pneumonia, will be able to read the sections on the specific pneumonias in Section II with greater understanding. References are included in considerable and sufficient number to provide adequate guidance to further reading.

1012 pp. 13 tables.

Price 84s., postage 2s. 9d.

7 & 8 Henrietta Street
London · W.C.2

HAGAN & BRUNER
Infectious Diseases of Domestic Animals
3rd Ed. 84s.

HARROP
Reproduction in the Dog
30s.

KELSER & SCHOENING
Manual of Veterinary Bacteriology
50s.

KIRK
Index of Diagnosis
4th Ed. 45s.

KIRK
Index of Treatment
3rd Ed. 45s.

LAING
Fertility and Infertility in the Domestic Animals
35s.

MARKOWITZ
Textbook of Experimental Surgery
4th Ed. 100s.

MÖNNIG'S
Veterinary Helminthology and Entomology
4th Ed. 42s.

NEWSOM'S
Sheep Diseases
2nd Ed. 72s.

PANTELOURIS
Handbook of Animal Physiology
25s.

SMYTHE
Veterinary Ophthalmology
2nd Ed. 42s.

WILLIAMS
Veterinary Obstetrics
4th Ed. 90s.

WIRTH
Veterinary Clinical Diagnosis
First English Ed. 25s.

THE THINGS A COW WILL EAT

cintel metal detector

RANK CINTEL LIMITED
WORSLEY BRIDGE RD., LONDON, S.E.26
HITHER GREEN 4600

This photograph — reproduced by permission of "Farmers Weekly" shows just part of a collection of metal articles found in cows' stomachs.

The Journal of Comparative Pathology and Therapeutics

(Founded in 1888 by Sir John M'Fadyean)

The Journal is devoted to the publication of papers recording original research in veterinary science. It is published quarterly.

Price 60/- net per volume of four numbers. Single copies 17/6.

PUBLISHED BY

Liverpool University Press

123 Grove Street, Liverpool 7, England

Animal Breeding Abstracts

will keep you up to date with research in livestock breeding and genetics

By means of abstracts, review articles, book reviews and news items, this journal covers the world's published research on breeds, breeding, productivity, genetics and reproduction of all farm livestock, as well as poultry and fur bearers. Experimental work with small laboratory animals is also reported in so far as it may throw more light on problems connected with animals of economic importance.

Prepared by the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh, and issued quarterly in March, June, September and December at 65s. per annum.

Subscriptions and enquiries should be sent to

Commonwealth Agricultural Bureaux

Central Sales Farnham Royal Bucks.

THE THINGS A COW WILL EAT

cintel metal detector

RANK CINTEL LIMITED
WORSLEY BRIDGE RD., LONDON, S.E.26
HITHER GREEN 4600

This photograph — reproduced by permission of "Farmers Weekly" shows just part of a collection of metal articles found in cows' stomachs.

The Journal of Comparative Pathology and Therapeutics

(Founded in 1888 by Sir John M'Fadyean)

The Journal is devoted to the publication of papers recording original research in veterinary science. It is published quarterly.

Price 60/- net per volume of four numbers. Single copies 17/6.

PUBLISHED BY

Liverpool University Press

123 Grove Street, Liverpool 7, England

Animal Breeding Abstracts

will keep you up to date with research in livestock breeding and genetics

By means of abstracts, review articles, book reviews and news items, this journal covers the world's published research on breeds, breeding, productivity, genetics and reproduction of all farm livestock, as well as poultry and fur bearers. Experimental work with small laboratory animals is also reported in so far as it may throw more light on problems connected with animals of economic importance.

Prepared by the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh, and issued quarterly in March, June, September and December at 65s. per annum.

Subscriptions and enquiries should be sent to

Commonwealth Agricultural Bureaux

Central Sales Farnham Royal Bucks.

NOTICE TO CONTRIBUTORS

1. *The British Veterinary Journal* publishes original papers and reviews on all aspects of veterinary science and kindred subjects. Accounts of clinical observations are published and, in the form of letters to the editor, preliminary reports of scientific studies. Reviews should, in general, be written in support of original investigations.

2. *Manuscripts*, written in the English language, should be sent to the Editor, *The British Veterinary Journal*, 7 and 8 Henrietta Street, London, W.C.2. Papers are accepted for publication on the understanding that they have not been published and are not being considered for publication elsewhere, and that they may not be re-published without sanction from the publishers.

3. Contributions, which may be subject to editorial revision, should be condensed as far as possible and should be submitted as a top typewritten copy on one side of the paper only, with double spacing and ample margins. The spelling should be that of the Oxford English Dictionary.

4. Manuscripts should be headed with the title of the paper, the name and postal address of the author or authors, or, where applicable, the address of the institution where the work was done. They should conclude with a factual summary equal to about 3 per cent. of the length of the paper. References to previous work should be cited in the text with the author's name and the year of publication in parentheses, e.g. "Brown (1957) showed that . . ." Where there are more than two authors the names of all should be cited on the first occasion in the text and thereafter only the first followed by *et al.*, e.g. "Brown *et al.* (1957) . . .". In the list of references at the end of the paper all the authors' names and initials should be included. The references should be listed in alphabetical order of the surnames of the authors, and the titles of the journals should be abbreviated in accordance with the *World List of Scientific Periodicals*, e.g. Brown, A. B. (1957) *Brit. vet. J.*, **113**, 217.

5. *Illustrations* should be numbered in arabic numerals in the order in which they appear in the text and all referred to as "figures," and should be somewhat larger than the size desired for reproduction. Drawings, diagrams and graphs should be in black ink on Bristol board or stout, smooth white paper. Letters and numbers should be indicated on them lightly in pencil. Photographs and photomicrographs should be printed on glossy paper. X-ray films should not be submitted, but prints of them, preferably negative prints. The areas to be reproduced of the photographic illustrations, if less than the whole, should be outlined *lightly* in pencil on the back of each. All illustrations, diagrams, etc., should bear on the reverse side the author's name, a short title of the paper and a figure number. Legends should be typed on a separate sheet of paper and should not be attached to the illustration. A statement of the magnification of illustrations should be given where it is applicable.

6. Illustrations in colour can be accepted provided that the author is willing to bear the cost of their reproduction. Authors may also be required to contribute to the costs of reproducing black and white illustrations in cases when the costs are particularly heavy.

7. *Tables* should be typed on separate sheets and numbered in roman numerals in the order in which they are referred to in the text and their size and number should be limited to the minimum necessary for clarity.

8. *A proof* of each article is sent in duplicate to the author. Minor corrections to the proof are permitted, but major alterations will be carried out only at the author's expense.

9. *Reprints* of articles and extra copies of the journal can be supplied if they are ordered when the galley proofs are returned to the publishers. An order form is sent out to authors with the proofs. A copy of the journal and twenty off-prints of each article are supplied free and will be sent to the author, or to the senior author if there is more than one, as soon as the article has been published.

Annual subscription, 42s. post free (U.S.A. and Canada, $7.00) payable in advance.
Special students' subscription rate, 30s. post free.

LONDON: PRINTED FOR BAILLIÈRE, TINDALL AND COX, LTD., 7-8 HENRIETTA STREET, COVENT GARDEN, W.C.2.
FERGUS BROWN & CO. LTD., 37 MARTIN'S PRESS, 22 BAKER'S ROW, LONDON, E.C.1.